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New Aspects of Product Risk Measurement and Management in the U.S. Life and Health Insurance Industries

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New Aspects of Product Risk Measurement and Management in the U.S. Life and Health Insurance Industries

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New Aspects of Product Risk Measurement and Management in the U.S. Life and Health Insurance Industries

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Product risk is important to firms' enterprise risk management. This dissertation focuses on product risk in the U.S. life insurance and health insurance industries. In particular, we add new dimensions to the measurement of product risk for these industries, and we explore how these industries manage product risk in a context of other enterprise risks.

In this dissertation, we identify new product risks, propose new measures, and study the management of these risks. In the life insurance industry, we identify a new type of product risk, the *guarantee risk*, caused by variable annuities with guaranteed living benefits (VAGLB). We propose a value-at-risk type measure inspired by the risk-based capital C3 Phase II to quantify the guarantee risk. In the health insurance industry, where the degree of uncertainty varies for different types of health insurance policies, we

develop four exposure-based risk measures to capture health insurers' product risks. Then we study how life and health insurers manage product risks (and asset risks) by using capital in the context of other risks and appropriate controls. We add to the literature in the life insurance industry by examining the relationship between capital and risks when the guarantee risk is accounted for. In the health insurance industry, to our knowledge, no similar research on the relationship between capital and risks has been conducted. In view of the current topicality of health insurance, our research therefore adds a timely contribution to the understanding of health insurer risk management in an era of health care reform.

Capital structure theories, transaction cost economics, and insurers' risk-taking behaviors provide the theoretical foundation for our research. As to methodology, we implement standard capital structure models for the life and health insurance industries using data from the National Association of Insurance Commissioners (NAIC) annual filings of life/health insurers and health insurers. Simultaneous equations modeling is used to model life and health insurers' enterprise risk management. And the estimation is conducted by the generalized estimation equations (GEE).

We find that both U.S. life/health insurers and health insurers prudently build up capital as they experience more product risk and asset risk controlling for the other enterprise risks. We also find that life/health insurers may be using derivatives as a partial substitute for capital when managing new product risk caused by VAGLB, the guarantee risk.

TABLE OF CONTENTS

Introduction……………………………………………………………………. . 1

Chapter 1

An Overview of Life and Health Insurers' Enterprise Risks and Risk Management by Capital and Hedging……………………………...…. 7

1.1 Product Risk of Life and Health Insurers……………………………………... 7

1.1.1 Product Risk………………………………………………………………… 7

1.1.2 Life Insurers' Product Risk…………………………………………….... 17

1.1.3 Health Insurers' Product Risk…………………………………………... 20

1.2 Other Enterprise Risks of Life and Health Insurers…………………………….. 25

1.2.1 Other Enterprise Risks and Proxies…………………………………….. 25

1.2.2 Life Insurers' Enterprise Risks…………………………………………. 30

1.2.3 Health Insurers' Enterprise Risks………………………………………. 39

1.3 Insurers' Risk Management by Capital and Hedging………………………….. 52

1.3.1 Insurers' Risk Management Tools……………………………………... 52

1.3.2 Literature Review……………………………………………………… 60

1.3.3 Risk-Taking Behavior Hypotheses…………………………………….. 72

Chapter 2

New Product Risk Measures of U.S. Life and Health Insurers……….. 74

2.1 New Product Risk Measure for U.S. Life Insurers……………………….……….. 74

2.1.1 New Product and Related Product Risk…………………….………... 74

2.1.2 New Product Risk Measure – Guarantee Risk……………….………. 79

2.2 Product Risk Measure for U.S. Health Insurers…………………………..…….. 92

2.2.1 Health Insurers' Product Risk…………………………………...…… 92

2.2.2 Product Risk Measure for U.S. Health Insurers…….…………………... 98

Chapter 3

Product Risk Management in the Context of Other Enterprise Risks.100

3.1 Risk Management by Capital under New VAGLB Product Risk in U.S. Life Insurance Industry……………………………………………………………….. 100

3.1.1 Hypothesis to Be Tested ..……………………………...……….….. 100

3.1.2 Data and Summary Statistics………………………………………….. 101

3.1.3 Empirical Methodology……………………………………………….. 106

3.1.4 Empirical Results and Discussion…………………………………….. 107

3.2 Risk Management by Capital in U.S. Health Insurance Industry……………... 111

3.2.1 Hypotheses to Be Tested……………………………………………… 111

3.2.2 Data and Summary Statistics………………………………………….. 113

3.2.3 Empirical Methodology……………………………………………….. 121

3.2.4 Empirical Results and Discussion…………………………………….. 123

Summary………………………………………………………...……………..128

Bibliography……………………………………………………...…………….134

Introduction

Insurance companies are financial institutions that perform two principal functions: They price and underwrite risks, and they invest the premiums that they are paid for assuming those risks. Policyholders transfer some of the financial consequences of risks of various perils to insurers in exchange for premium payments. Insurers invest pools of premiums in real estate and financial instruments, thus providing a source of liquidity to support the growth and development of the economy. The financial health of the insurance industry is therefore of considerable importance. In particular, the practices by which insurers manage the risks of their products, of their investments, and of other aspects of their endeavors are of great concern. In this dissertation, we focus on the U.S. life insurance and health insurance industries. Among various enterprise risks faced by life and health insurers such as asset risk, product risk and regulatory risk, we focus on their product risk. Specifically, we develop a new method to quantify life insurers' new product risk generated by variable annuities with guaranteed benefits and find proper product risk measures for health insurers. Then we study their use of capital (and derivative hedging for life insurers only) to manage the risks emanating from their products, in particular, and from other aspects of their activities in general.

U.S. life and health insurance industries are confronted with opportunities and challenges. Financial market innovation enables life insurers to expand their lines of business and create variable annuities with guarantees. However, increasing market volatility and the ongoing recession challenge life insurers' ability to manage the new risk inherent in this new product. The business activity of health insurers is likely to increase substantially after new healthcare legislation is fully in effect in 2014. However, continuously increasing medical costs and more federal government regulations make risk management of various health insurance products become health insurers' top priority.

For life insurers, in the past two decades, the boom in financial markets and increasing consumer demand for hedging longevity risk nurtured the rapid growth of the variable annuities with guaranteed benefits (VAGB) market. Differing from traditional variable annuities in which gain or loss of account value is solely at the annuitants' own risk, VAGB provides annuitants various guarantees to protect account value from downside market risk while still preserving the potential for the annuitant to profit from upside markets. Life insurers profit from VAGB by collecting fees for providing the various guarantees.[1] However, insurers confront exposure to the contractual guarantees of VAGB products. These exposures created challenges during the financial crisis that began in late 2007. In a market downturn, guarantees of VAGB contracts are triggered. Life insurers are obligated to cover the gap between annuitants' real account value and the guaranteed contract value. In this way, VAGB guarantees added to the distress of life

[1] "From 2003 to 2007, U.S. life insurance industry's revenues grew by 15% or $108 billion, reaching $830 billion in 2007, and cumulative profits over five years amounted to $165 billion. The main driver of the performance is variable annuities. In 2007, variable annuities sales amounted to $172 billion." Responding to the Variable Annuities Crisis, McKinsey Working Papers on Risk, 2009 McKinsey & Company.
"Living benefits are still driving retail VA sales, and in excess of 85% of VAs sales contain a living benefit rider." Annuity Product Development Trends and Issues – VA Perspective, SOA Annual Meeting Session 26, Kevin Roper, FSA MAAA, AEGON Transamerica, October 2010.

insurer balance sheets that were simultaneously being damaged by mortgage-backed securities and sinking equity and bond markets.

Health insurers are faced with big challenges in rising medical costs and legislation. In the U.S., health insurers are important financial intermediaries in the healthcare delivery system. Health insurers underwrite risks of medical expenses, collect premiums from policyholders upfront and make payments to healthcare providers after medical services are delivered. Therefore, health insurers are at the risk of realized medical expenses surpassing collected premiums. In fact, driven by technology and prescription drugs, chronic disease, aging of the population and administrative cost, U.S. healthcare cost has been rising so fast that expenditure in healthcare already surpassed $2.3 trillion in 2008.[2] In addition, health insurers might experience still more pressure after adoption of the Patient Protection and Affordable Care Act (PPACA). By imposing elimination of benefit caps, guaranteed insurability, and loss ratio minima, PPACA is likely to expose health insurers to more uncertainties regarding healthcare costs while attempting to control for premiums charged.

Whether U.S. life and health insurers can meet these challenges and manage increasing risks well is important to the financial stability of the whole society. One major purpose of this dissertation is to shed light on life and health insurers' possible risk management strategies toward new risks together with other enterprise risks by empirically investigating their historical risk-taking behaviors. Our approach is to extend

[2] See "U.S. Healthcare Costs" at http://www.kaiseredu.org/Issue-Modules/US-Health-Care-Costs/Background-Brief.aspx

research on insurers' product risks, which are uncertainties embedded in various insurance policies they underwrite. Incorporating new measures of product risks, we study the use of capital (and derivative hedging for life insurers only) to manage major life and health insurer risks.

We identify new product risks, propose new ways to measure risk and empirically analyze the management of these risks. In the life insurance industry, we identify a new type of product risk, the *guarantee risk*, caused by variable annuities with guaranteed living benefits (VAGLB). We propose a value-at-risk type measure inspired by the risk-based capital C3 Phase II to quantify the guarantee risk. In the health insurance industry, we do not identify new product risks but we acknowledge that the degree of uncertainty varies for different types of health insurance policies. And taking that into account, we develop four exposure-based risk measures to capture health insurers' product risks. Then we study how life and health insurers manage product risks together with certain other enterprise risks by using capital in the context of other risks and appropriate controls. Our findings suggest that both life and health insurers will need more capital to prepare for increasing product risks if they wish to avoid an increase in overall risk.

The theoretical foundation for our research includes capital structure theories, transaction cost economics, and insurers' risk-taking behaviors. As to empirical methodology, we employ simultaneous equation modeling in which the estimation is conducted by generalized estimating equations (GEE). The dataset we use for our analysis is provided by the National Association of Insurance Commissioners (NAIC).

For analysis of the life insurance industry, we use life insurers' annual filing 2006 – 2007. For analysis of the health insurance industry, we use health insurers' annual filing 2001 – 2008.

Structure of the Dissertation

In Chapter 1, we discuss life and health insurers' major enterprise risks and theories and methodologies used in our research. In particular, we focus on attributes of life and health insurers' product risks. Chapter 1 comprises three sections. In the first section, we define life and health insurers' product risks and review existing product risk measures. In the second section, we describe other enterprise risks of life and health insurers and their relationships with insurers' products. In the third section, we first examine two insurers' major risk management tools, capital and hedging. Then we review the literature on theoretical foundations and empirical research in the other industries. Finally, we propose hypotheses testing risk-taking behaviors for life and health insurers.

Chapter 2 is exclusively about product risks. For life insurers, we identify the new product risk, *guarantee risk*, generated from life insurers' innovative product, variable annuities with guaranteed benefits. Then we explain how we measure guarantee risk using a value-at-risk type measure. For health insurers, we first summarize factors related to their product risks. Then we formalize four exposure-based product risk proxies.

Chapter 3 focuses on empirical analysis of insurers' enterprise risk management using product risk proxies proposed in the previous chapter. For both life and health insurers, we first describe the NAIC insurers' annual statement datasets by presenting extensive summary statistics. Then we describe the estimation methodology for the empirical models that we employ. Finally, we discuss the empirical results, implications and suggest future studies.

Chapter 1

An Overview of Insurers' Enterprise Risks and Risk Management by Capital and Hedging

1.1 Product Risk of Life and Health Insurers

1.1.1 Product Risk

Definition of Insurers' Product Risk

Risk is defined as the uncertainty about a future outcome.[3] In finance, risk is usually measured by variability of uncertain future outcomes. Product risk is the uncertain consequence that arises from the nature and use of firms' products or services. It takes different forms in different industries. For manufacturing industries, defects of products or inadequate instructions causing customers' loss are known as manufacturers' product liability risk. For financial industries, complex structured financial transactions resulting in investors' economic loss can also expose financial institutions to product risk. We will adapt the general concept of product risk to the insurance industry. In particular, we will analyze factors contributing to insurers' product risk by using a statistical model.

Like other financial institutions, insurers market services rather than physical products. Insurers sell the assumption of risk, manifested as an insurance policy, or contract, that specifies the terms and conditions of the risk transfer. With some abuse of

[3] Etti Baranoff, Patrick Brockett, and Yehuda Kahane, *Risk Management for Enterprises and Individuals*, 1st edition.

terminology, insurers commonly refer to these policies as "products", by analogy with manufacturing firms. Insurers relieve their customers of some of the financial consequences of risks of ill health, death, loss of income, and other perils in return for premium payments that insurers accumulate and invest. The insurer is under no obligation to return any invested funds to its customers – unless and until the occurrence of triggering conditions specified in the policies. The prudent insurer maintains reserves sufficient to pay actuarially anticipated claims arising from triggered policies.

We may define insurers' product risk broadly as the uncertainty over whether collected premiums will cover future claims cost and costs of underwriting and administration. Premiums are prices insurers charge for reducing policyholders' risks as specified in insurance contracts. Premiums are determined by estimates of the frequency and severity of future claims. However, the actual claims cost is only known afterwards when future claims happen. Therefore, it is uncertain whether collected premiums are sufficient to cover claims cost until the claims cost is realized. But the more accurate estimates on future claims reduce insurers' uncertainties or risks carried in a specific product.

Examining insurance theories can help us understand insurers' product risk. The insurance business is built on risk reduction by risk pooling. By pooling a large number of homogeneous and independent loss exposures into classes, insurers realize risk reduction. Cummins (1974 and 1991), and Bowers, et al. (1986) use what they call individual risk theory to explain how insurance realizes risk reduction.

The following is a simple statistical model to illustrate insurers' future claims cost. Suppose the total amount of claims in one year for a certain insurance product is a random variable S_N, which is simply the sum of individual exposure units, X_i. N is the number of individual exposures.

$$S_N = \sum_{i=1}^{N} X_i$$

S_N = total amount of claims in one year

X_i = claim of exposure unit i

N = number of individual exposure in the pool

μ = mean loss per exposure unit

σ^2 = variance of loss of each exposure unit

σ_{ij} = covariance of the ith and jth exposure units

If individual claims are identically distributed, the mean and variance of insurers' total claim cost will be:

$$E(S_N) = E(\sum_{i=1}^{N} X_i) = N\mu$$

$$Var(S_N) = Var(\sum_{i=1}^{N} X_i) = N\sigma^2 + 2\sum_{j=2}^{N}\sum_{i=1}^{j-1}\sigma_{ij}$$

If there is no covariance among exposure units (σ_{ij} = 0), the variance of total claim cost will be $N\sigma^2$. According to the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT), as long as the mean and variance of individual loss exposure are finite and N is large enough, the mean or average of individual loss exposure follows a normal distribution approximately:

$$\overline{X} \sim N(\mu, \frac{\sigma}{\sqrt{N}})$$

By pooling loss exposures with homogeneous risk defined by σ, for the insurer, the risk of loss exposure has been reduced from σ for an individual to $\sigma / \sqrt{N}$ for the mean. Accordingly, the risk of total claim loss is $\sqrt{N}\sigma$. In other words, for insurers, risk of each exposure unit on average decreases with more members in the pool, but the total claim loss risk still goes up with more exposure units. If the covariance among exposure units is not zero, the risk of total claim loss will be $\sqrt{N\sigma^2 + 2\sum_{j=2}^{N}\sum_{i=1}^{j-1}\sigma_{ij}}$, and positive correlation of exposure units increases the risk of total claim loss. Using this model, insurers' product risk can actually be interpreted as how accurately insurers measure risk of individual exposure unit and the extent of correlation among exposure units.

Whether insurers can measure risk of individual exposure well depends on the extent to which insurance coverage is explicitly defined. As we discussed already, insurance products are essentially financial contracts, which are supposed to specify coverage explicitly – the benefits and obligations for both insurers and policyholders. Insurers' actuarial pricing is based on coverage specifications in the contract. Therefore, an implicitly specified insurance contract might result in inaccurate estimation of risk of individual loss exposure unit (σ), which increases the insurers' product risk. The connection between the implicitly specified insurance contract and risk exposure is based on contract theory and transaction cost economics (TCE) introduced by R. H. Coase and further developed by Oliver Williamson (1975, 1985, and 1990). Baranoff (1993) applied contract theory and TCE on life insurers' product risk analysis. The author differentiated risk levels for life insurers' major lines of business by completeness of insurance contracts. Low, medium and high risk levels are assigned to annuities, life insurance, and health insurance, respectively.[4]

Another factor contributing to insurers' product risk is the covariance or correlation among individual exposure units. Using the formula for risk of total claim loss, negative covariance of exposure units helps to reduce insurers' product risk, while positive covariance results in greater product risk. The difficulty of measuring covariance of individual exposure units is that covariance or correlation could change suddenly after some triggering event. Triggering events could be natural or man-made disasters, catastrophes and pandemic diseases, etc. Insurers might be confronted with a sudden spike in product risk because of these events. Under these circumstances, insurers' reserve could be exhausted because of the loss exposure in the affected area. Allstate Corp. reported that severe weather drove up catastrophic losses to $2 billion in the second quarter of 2011.[5] Also, pandemic disease such as swine flu (H1N1), avian flu (H5N1) and SARS resulted in big losses for both life/health insurers and property/casualty insurers. The recent financial crisis severely affected insurers as rising covariances spread the crisis contagiously.

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[4] Williamson described three types of contracts in his book "The Economic Institutions of Capitalism" (1985): classical contracts, neoclassical contracts, and relational contracts. Classical contracts are for the transaction of standard products or resources; neoclassical contracts are designed for non-standard products, which are riskier than classical contracts; while relational contracts, the most risky ones, are subject to more uncertainties that cannot be specified in the contracts. Baranoff (1993) applied this framework to life insurers' product portfolio.

[5] "Allstate says 2Q catastrophe losses reach $2B", The Wall Street Journal, June 16th 2011.

As the name suggests, variable annuities with guaranteed benefits provide annuity holders a guaranteed account value regardless of the current market performance. This means that life insurers must guarantee policyholders either return of the amount of initial investment, certain annual income or roll-up, or flexible withdrawals. Premiums for insurance-type guarantees are fees charged to variable annuity accounts. However, the 2008 financial market crash made the majority of variable annuity accounts lose money, directly challenging life insurers providing VAGB products. Meanwhile, on the left-hand-side of the balance sheet, life insurers' asset portfolios depreciated at the same time aggravating the situation and depleting their capital.

So far, we have defined product risk for insurers. Using a simple model in individual risk theory, we explained possible sources of product risk by decomposing insurers' product risk into individual risk and the correlation between individual risks. In the following section, we will discuss empirical measures to assess insurers' product risk.

Methods to Assess Insurers' Product Risk

We focus on exposure-based risk measure and volatility-based risk measure to empirically quantify product risk. We developed a risk measure diagram (Figure 1.1) showing the major and subtypes of risk measures. The following discussion is based on the order of Figure 1.1.

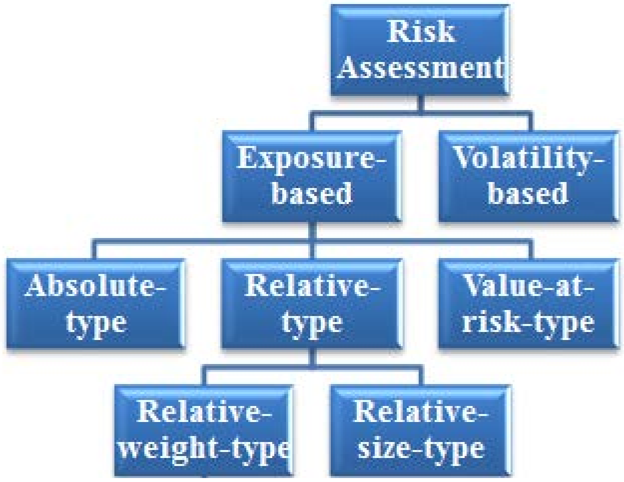

Figure 1.1

Exposure-based Risk Measure

"Exposure" refers to the condition of being at risk of financial loss or an amount of at risk.[6] In risk management and insurance studies, exposure is also a term used to describe the enterprise, property, person, or activity facing a potential loss.[7] In our understanding, exposure may contribute to risk level from two perspectives: actual amount of potential losses and uncertainty of losses of exposure units. Higher risk level is associated with larger amount and/or greater uncertainty of losses.

Exposure-based risk measure can be used to quantify insurers' enterprise risks such as product risk and asset risk on different aspects. It forecasts the magnitude of potential financial loss caused by insurers' underwriting and investment activities. It can also represent insurers' product risk and asset risk by examining the composition of

[6] Merriam-Webster online dictionary: http://www.merriam-webster.com/dictionary/exposure
[7] Risk Management for Enterprises and Individuals, Etti Baranoff, Patrick Brockett and Yehuda Kahane, Flat World Knowledge, Inc.

insurers' product and asset portfolio. Higher risk level is assigned to product and asset portfolios concentrating on product and asset types with greater uncertainty. However, an exposure-based risk measure is not capable of capturing the fluctuation of financial losses or changes of insurers' product and asset portfolio concentration overtime.

Exposure-based risk measure is essentially measuring risks by size of exposures. Exposure-based risk measures can take different forms. Major forms can be absolute, relative and value-at-risk types.

(i) Absolute-Type Exposure-based Risk Measure

The absolute-type exposure-based risk measure uses the actual size of exposure. For instance, suppose that a life insurance company underwrote life insurance contracts totaling $10 million at face value. Actuarial calculation will forecast possible claims and record corresponding reserves for those contracts. The size of forecasted loss exposure, reserves, and face value all represent the magnitude of potential loss. Therefore, they can serve as an absolute-type exposure-based risk measure for the life insurance contracts.

(ii) Relative-Type Exposure-Based Risk Measure

Relative-weight and relative-size are subtypes of relative-type exposure-based risk measure. The relative-weight measure focuses on weight or allocation of risk exposures on different risk levels of exposure units. For instance, life/health insurers' product portfolios comprise life insurance, annuities, and health insurance. A percentage of writings for a specific product to total writings can be used to proxy insurer's product risk.[8] This measure focuses on insurers' product concentration. An insurer concentrating on highly risky product experiences greater product risk. Two insurers with the same magnitude of absolute exposure-based product risk might exhibit quite different relative-weight-type exposure-based product risk because they might focus on different lines of business or product. On the other hand, relative-size exposure-based risk measure incorporates firm size as a scale. Insurers' size can be measured by total assets, liabilities, writings and premium income. An insurance policy with a given amount of loss exposure[9] might be on a different risk level for a large insurer vis-à-vis a small insurer because a large insurer usually has a larger risk pool than a small insurer. Therefore, loss exposure relative to insurer size is a better risk measure than absolute-type risk measure when it comes to cross-sectional analysis.

(iii) Value-at-Risk Exposure-Based Risk Measure

The value-at-risk exposure-based risk measure (VaR) has been widely-used in financial industries. After the 1987 financial crisis, financial industries were in great need of risk management measures that could describe or capture their possible losses under extreme events. Developed by J.P. Morgan in 1994, VaR was later accepted by the U.S. Security and Exchange Commission (SEC) and Basel II Accord worldwide as a standard measure for market risk.[10] "VaR calculates the worst loss over a given horizon at a given

[8] Baranoff and Sager (2002) developed product risk for life insurance industry in this way.
[9] Assuming large and small insurers are underwriting similar insurance products for similar risk pools.
[10] "Value at Risk: The New Benchmark for Managing Financial Risk", Jorion, Phillppe, McGrow-Hill, 2006

confidence level under normal market conditions."[11] In essence, VaR calculation is based on probability distribution of loss for a given portfolio generated by Monte Carlo simulation in a specific time horizon. The VaR calculation usually goes through the following processes: determine the time horizon; select degree of certainty required; create a probability distribution of likely returns for portfolio under consideration; and finally read the VaR result from the distribution created.[12] Even though it is a commonly used risk measure in the industry, VaR has met with criticisms such as the sub-additive problem.[13] Berkowitz and O'Brien (2002) found that banks' reporting ex ante VaR forecasts underestimated their risk. In chapter 2 section 1 of this dissertation, we will show calculation of VaR exposure-based risk measure step by step.

Volatility-Based Risk Measure

Volatility-based risk measure is widely used to quantify risk of financial instruments and portfolios. In finance, volatility is calculated as the standard deviation of returns of financial instruments in a given time horizon. Historical volatility, implied volatility and stochastic volatility can all be measured. In this dissertation, we focus on historical volatility. Using volatility-based risk measure, we are actually defining risk as variation or standard deviation in statistics. The more volatile or the greater the standard deviation of a financial instrument's return is, the more risky the financial instrument is. As an ex ante risk measure, volatility-based risk measure has the disadvantage that it is

[11] "Value-at-Risk: An Overview of Analytical VaR", Roman Berry, Investment Analytics and Consulting, September 2008

[12] "VAR Understanding and Applying Value-at-Risk", KPMG Risk Publications, 1997

[13] 'Sub-additive problem' means that the portfolio VaR can be greater than the sum of VaRs of portfolio's instruments. "Measuring Market Risk", Dowd, Kevin, John Wiley & Sons, 2005.

affected by time horizon, which means that the risk changes with the historical time period. As a popular methodology to quantify financial risks, volatility-based risk measure can also be used to measure the product risk. However, the effectiveness of this measure when applied to product risk depends on the variability of product risk exposures overtime.

The above discussion covered some commonly used risk measures. For industry-wise study, we suggest the relative exposure-based risk measure to quantify insurers' product risk for the following reasons. First, we have already argued above the advantage of relative measures to absolute measures. Second, the business-strategy hypothesis (see Baranoff and Sager 2003) suggests that product focus should be a relatively stable choice for insurers. If the product focus does not vary frequently, then the volatility of product risk may be relatively low. Moreover, insurers file financial statements to NAIC on an annual or quarterly basis, thus providing only sparse historical data for the calculation of volatility. Thus, volatility-based product risk measures may not be as appropriate a measure for capturing product risk as it is for market risk.

1.1.2 Life Insurers' Product Risk

<u>Life Insurers' Products</u>

U.S. life insurers' major insurance products include life insurance, annuities, accident and health insurance, reinsurance and deposit type insurance such as Guaranteed Insurance Contracts (GICs). The major types may be further divided into subtypes by coverage or terms and conditions. Life insurance is thus classified into term life, whole life, universal life, variable life and variable universal life insurance products.[14] An annuity provides for an accumulation period, the time when premiums are paid to the insurer, and a payout period, the time when the insurer pays out income to the annuitant. An annuitant can select fixed or variable income payouts and deferred or immediate payout start.[15] Accident and health insurance covers a broad spectrum of products such as comprehensive, dental, vision, disability and long-term care.[16] On U.S. life insurers' annual filing to National Association of Insurance Commissioners (NAIC), they also report life, annuities, accident and health products separated by types of policyholders, which can be individual or group. Table 1.1 shows aggregate premiums for each major line of life insurers' business from 2005 to 2008.

Table 1.1 Life Insurers' Premiums Writings by Line of Business (in millions of dollars)

Year	Life Insurance	Annuities	Accident & Health	Reinsurance	Total*
2005	$155,363	$288,552	$122,523	$58,667	$626,431
2006	$166,247	$310,579	$142,892	$61,472	$681,189
2007	$184,139	$327,635	$154,786	$69,724	$736,284
2008	$170,157	$347,147	$168,644	$72,579	$758,529

* Total writing is greater than the sum of life insurance, annuities, accident & health and reinsurance because there are other miscellaneous products

Understanding certain aspects of life insurer accounting will facilitate an understanding of how product risks affect life insurers. Life insurers keep two account books to distinguish their own finances from fiduciary client finances. Life insurers account for their own finances in the general account and for fiduciary funds in the

[14] "Risk Management and Insurance", E.G. Baranoff, Wiley, 2004
[15] "Risk Management and Insurance", S.E. Harrington and G.R. Niehaus, McGraw-Hill Irwin, 2004
[16] Baranoff (1993) documented extensively life insurers' products.

separate account. On the general account, life insurers' product risk arises from the adequacy, or not, of reserves for all future claims. If claims surpass actuarial reserves, life insurers must allocate capital to close the gap. The separate account is to record lines of business such as variable life, variable annuities, modified guaranteed annuities, and securities lending, which involve investment features in the insurance contracts. The value of the separate account is marked to market. Absent the guarantee features of some variable annuity products, life insurers are not responsible to policyholders for gain or loss in the separate account. However, given the guarantees of some variable annuities, it is possible for life insurers' separate account liability to surpass reserves. Under this circumstance, life insurers will transfer capital from their general account to the separate account. By this means, VAGB adds another dimension to life insurers' product risk. We will discuss this risk in detail in chapter 2. Since 2010, the NAIC has required life insurers to disclose more of their activities in separate accounts on the general account annual filing. For example, the NAIC requires life insurers to report the amount paid by the general account to the separate account due to separate account guarantees for variable annuity products during the past five years.[17]

Existing Product Risk Measure for Life Insurers

Baranoff and Sager (2002) developed relative-weight exposure-based risk measure to quantify life insurers' product risk. Specifically, they use the ratios of premium writings of life insurers' major lines of business, life, annuities, health, and reinsurance, to total premiums writings. Baranoff and Sager (2002) also presented a

[17] "Blanks Agenda Items Submission Form", NAIC Blanks Working Group, November 2009

theoretical foundation using contract theory and transaction cost economics to differentiate product risk levels for major lines of business. Since product risk levels of different lines of business are intrinsically different, a product risk measure capturing weights allocated to different products works better than the measure by exposure relative to firm size. Table 1.2 presents the distribution of life insurers' product risk as a measure developed by Baranoff and Sager (2002).

Table 1.2 Life Insurers' Major Lines of Business Premiums Writings to Total Writings †

	P1	Median	P3	Mean	Stdev	P1	Median	P3	Mean	Stdev
	2005					2006				
Plife	0.018	0.301	0.756	0.397	0.378	0.018	0.301	0.760	0.402	0.402
Pannuity	0	0.001	0.187	0.168	0.300	0	0.000	0.174	0.167	0.301
Phealth	0	0.039	0.553	0.276	0.365	0	0.035	0.534	0.276	0.368
Preinsur	0	0.001	0.106	0.158	0.314	0	0.001	0.113	0.155	0.353
	2007					2008				
Plife	0.017	0.316	0.788	0.405	0.388	0.018	0.293	0.777	0.398	0.385
Pannuity	0	0.000	0.143	0.162	0.298	0	0.000	0.177	0.172	0.307
Phealth	0	0.031	0.570	0.280	0.374	0	0.032	0.552	0.276	0.370
Preinsur	0	0.001	0.097	0.152	0.319	0	0.001	0.102	0.152	0.309

† P1 and P3 are the 25th percentile and 75th percentile. Plife, Pannuity, Phealth, and Preinsur are calculated as premium written in each line of business scaled by total written premiums.

1.1.3 Health Insurers' Product Risk

Health Insurers' Products

In the U.S., each insurer files an annual report with the NAIC in one and only one of the following categories Life, Health, or Property & Casualty. We used all insurers that file in the NAIC Health category. Insurers that file under the health category have self-identified as health insurers, their overwhelmingly predominant business is health insurance (medical coverage), and they write the majority of health business in the U.S.

There are many insurers that file with the NAIC under the Life category that also write a substantial amount of health policies. However, the Life category is much more heterogeneous and includes diversified insurers with interests in life, annuities, accident and health, and reinsurance lines. Because of their other interests, life filers with substantial health business may not behave as health insurers. Moreover, the reported data for Health filers is much richer and more useful for our purposes than for Life filers. Therefore, we limit our sample to Health filers.[18]

The major products that health insurers underwrite include Comprehensive, Federal Employee Health Benefits Plans (FEHPs), Medicare, Medicare Supplement or MediGap, Medicaid, Dental, Vision, other health related products (including disability, prescription drug and long term care).[19] Each product includes specific coverage. Comprehensive insurance, as its name implies, intends to cover nearly all ailments of the whole body (except dental and vision). It covers people under the age of eligibility for Medicare (generally 65). FEHPs have similar coverage as Comprehensive but are only for federal government employees. Medicare and Medicaid are social insurance. Health insurers involved with these programs usually have contracts with the Center for Medicare and Medicaid Services (CMS). Generally, Medicare is for people above 65 years of age with at least minimal financial means, whereas Medicaid is a welfare program for the very poor. Medicare Supplement is voluntary private insurance that

[18] In 2008, our sample numbered 878 health insurers and generated about $345 billion in health premiums. By comparison, there were 716 Life filers in 2008 that had at least some health business and collectively wrote about $170 billion in health premiums; but the Life premium figure is not directly comparable since it also includes accident and disability lines.

[19] "Official NAIC Annual Data Element Guide", National Association of Insurance Commissioners.

covers Medicare participants for certain expenses that are not covered by Medicare. Dental and Vision insurance provide limited coverage for certain medical problems of the teeth and eyes, respectively. Table 1.3 shows aggregate premiums by lines of business from 2005 to 2008 on products we discussed above.

Table 1.3 U.S. Health Insurers Total Premiums Income by Lines of Business

Products	2005	2006	2007	2008
Comprehensive	$168,356,784,480	$174,842,149,930	$181,926,170,780	$186,455,753,365
FEHPs	$19,762,520,243	$22,693,093,608	$24,679,756,725	$26,691,623,131
Medicare	$35,146,355,690	$46,536,223,658	$55,630,296,618	$65,961,900,823
MediGap	$7,683,594,238	$7,574,968,616	$7,443,773,107	$7,546,285,051
Medicaid	$27,137,990,458	$30,018,294,622	$37,216,451,970	$42,265,127,923
Dental	$6,245,785,466	$6,812,897,995	$7,239,510,422	$7,624,265,723
Vision	$893,005,260	$985,281,069	$1,239,934,050	$1,336,723,111
Other	$901,206,043	$7,461,366,112	$9,208,556,758	$8,243,480,334

The product risks of health insurers arise from the possibility that claims for medical services might surpass premiums collected. Baranoff and Sager (2002) argued that health insurers experience higher product risks than life insurers for several reasons. First, according to contract theory and transaction cost economics, health insurance contracts may be considered more incomplete and more relational than life insurance and annuity contracts. Second, the vagaries of law and regulation and the advance of medical technology create large uncertainties regarding the scope of health insurance coverage, regardless of contract specifications. Third, health insurers' cash flow systems are more complex than the other insurers. Health insurers are financial intermediaries for the healthcare delivery system. Unlike life or property and casualty insurers, which collect premiums from and pay claims to the same parties (i.e., policyholders), health insurers collect premiums from policyholders but pay claims to medical services providers. In this way, more agents with their respective uncertainties are introduced into the cash flow system, which increases health insurers' product risks.

Product Risk Measure for Health Insurers

We did not find previous literature proposing product risk measure for health insurers. Considering health insurance products' special features of inelastic demand and homogeneity under higher risk level, we use relative-size exposure-based risk measure to quantify health insurers' product risk. Exposure-based risk measure captures health insurers' product risk better than volatility-based risk measure because of the social product feature of health insurance. As a social product, the demand for health insurance is inelastic compared to life insurance and annuities. Under this circumstance, we are not expecting to see substantial volatility in health insurers written premiums, expenses or loss ratios over time. Furthermore, relative-size measure captures health insurers' product risk better than relative-weight measure. Relative-weight risk measure is most effective when product risk levels differ substantially as they do for life, annuities and health insurance products of life insurers. Product risk level of health insurers is more homogeneous. As we have argued, when measuring life insurers' product risk, health insurance policies are products with higher risk levels compared to life insurance and annuities. Therefore, the overall product risk of health insurers is comparatively high compared to life insurers. On an already high product risk level platform, relative-weight risk measure is not capable of capturing different product risk levels of each line of business well. However, relative-size risk measure tells clearly how much product risk there is in each line of business. Specifically, we measure health insurers' product risk by premium income scaled by insurers' total assets for each line of business. Table 1.4 shows the summary statistics for each line of health insurers' business.

Table 1.4 Summary Statistics for the Ratio of Health Insurers' Premiums to Total Assets, by Product Line *

	2005							2006					
Variable	N	P1	Median	P3	Mean	Stdev		N	P1	Median	P3	Mean	Stdev
Comprehensive	446	0.978	1.816	2.841	2.042	1.553		451	0.931	1.771	2.814	1.967	1.467
FEHPs	154	0.074	0.198	0.341	0.299	0.447		158	0.084	0.194	0.325	0.311	0.511
Medicare	217	0.13	0.570	1.571	1.184	1.812		257	0.201	0.728	1.742	1.250	1.557
MediGap	103	0.033	0.074	0.146	0.121	0.161		103	0.022	0.068	0.132	0.105	0.140
Medicaid	178	0.364	1.569	3.401	2.154	2.443		178	0.338	1.682	3.053	2.052	2.023
Dental	222	0.056	1.111	2.893	1.903	2.425		237	0.046	0.973	2.667	1.834	2.421
Vision	60	0.002	0.033	0.986	0.736	1.155		59	0.002	0.037	1.083	0.846	1.433
Other	52	0.044	0.171	0.951	0.706	1.159		103	0.027	0.141	0.550	1.785	11.671
	2007							2008					
Variable	N	P1	Median	P3	Mean	Stdev		N	P1	Median	P3	Mean	Stdev
Comprehensive	441	0.892	1.677	2.579	1.851	1.280		445	0.827	1.579	2.550	1.833	1.341
FEHPs	162	0.076	0.179	0.322	0.287	0.391		164	0.079	0.191	0.370	0.288	0.353
Medicare	297	0.189	0.775	1.905	1.401	1.944		338	0.177	0.785	2.185	1.424	1.759
MediGap	107	0.017	0.061	0.130	0.114	0.209		109	0.018	0.060	0.118	0.113	0.211
Medicaid	176	0.354	1.597	3.001	1.960	1.786		183	0.510	1.588	3.318	1.983	1.766
Dental	237	0.040	0.843	2.628	1.686	2.287		236	0.041	0.900	2.654	1.720	2.402
Vision	67	0.002	0.020	1.028	0.754	1.248		73	0.003	0.021	1.130	0.888	1.580
Other	150	0.020	0.066	0.319	0.408	0.903		145	0.022	0.065	0.367	0.495	1.059

* Summary statistics for a given product line exclude insurers that records 0 premiums in the line.

Here we have proposed relative-size exposure-based risk measure to quantify health insurers' product risk. In Chapter 2 Section 2.2, we will examine health insurers' products in a more extensive way to classify major products into groups and formally introduce product risk proxies for health insurers.

<u>1.2 Other Enterprise Risks of Life and Health Insurers</u>

1.2.1 Other Enterprise Risks and Proxies

<u>Other Enterprise Risks</u>

Enterprise risk is the broad spectrum of risks that an enterprise faces. The Casualty Actuarial Society Enterprise Risk Management Committee classified the major enterprise risks for a prototypical manufacturing firm into four groups: hazard risk, financial risk, operational risk, and strategic risk.[20] Hazard risk is the risk of loss caused by unexpected external reasons such as fire, personal injury, and property damage caused by natural perils, etc. Financial risk refers to uncertainties on enterprise's assets and cash flow caused by exposures to market risk, liquidity risk, credit risk, and interest rate risk. Operational risk is defined as "the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events".[21] In other words, operational risk is embedded in daily business operations. It can be, for instance, supply chain management failure, legal risk, or even inaccurate information because of wrong data input causing economic losses. For strategic risk, we did not find a formal definition. Casualty Actuarial Society Enterprise Risk Management Committee listed: "reputational damage, competition, customer wants, demographical and social/cultural trends, technological innovation, capital availability, and regulatory and political trends" as sources of strategic risk.

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[20] "Overview of Enterprise Risk Management", Casualty Actuarial Society Enterprise Risk Management Committee, May 2003.

[21] "Sound Practices for the Management and Supervision of Operational Risk", Bank for International Settlement: Basel Committee Publications No. 96. 2003

In enterprise risk management, some risks can be avoided, some risks need to be transferred, and some risks have to be managed. Firms can transfer hazard risk by purchasing insurance. Operational risk can be reduced by improving production process design and employee training. Part of the financial risk can be hedged using derivatives and diversification but not the entire financial risk exposure especially for financial industries. So financial risk and strategic risk are types of risks firms have to manage. For our study on insurers, we focus on financial risk and strategic risk.

Measures for Major Enterprise Risks

It is useful to review the major features of an insurer's structure and business operations before discussing measures. An insurance company manages two interrelated businesses: products and assets. The product side covers insurance business and the asset side is responsible for asset management. Insurance companies' core business is to underwrite insurance policies. Insurers can choose different organizational forms and distribution channels to facilitate their product focus.[22] There are two main types of organizational forms: stock and mutual. The difference between stock and mutual insurers is the ownership. Mutual insurers are owned by policyholders.[23] For stock insurers, owners and policyholders are different. The distribution system is the method by which insurers market their products. The major distribution channels are brokers, agents

[22] For property/liability insurance industry, Regan and Tzeng (1999) studied how insurers choose organizational form and distribution system simultaneously after product focus selection. For life insurance industry, Baranoff and Sager (2003) connected the study of life insurers' capital and risk decisions together with organizational form and distribution system.

[23] The two organizational forms are applicable to life and property/casualty insurers. Health insurers have more types of organizational forms such as non-profit, BC/BS, reciprocal, etc.

and direct sales. On the asset side, one major function of insurance companies is to invest collected premiums and generate investment income. In fact, insurance companies are important financial market makers. Insurers' major investment asset classes include bonds, stocks, mortgages, real estate, and short-term investments. By the end of 2008, the life insurance industry's total assets amounted to $4.6 trillion, bond holdings for the whole life insurance industry amounted to $2.2 trillion, and common stocks were approximately $104 billion.[24] The insurers' responsibility is not only to allocate assets into different classes, but also to monitor and timely adjust the asset portfolio risk so that duration and convexity of asset portfolio on the asset side match insurers' liabilities generated from their product side.

Underwriting and asset management activities carry financial and strategic risk. Insurers' NAIC annual filings provide detailed information on underwriting and asset management activity. Using these data, we quantify insurers' major risk exposure such as product risk and asset risk in regular business operations. These risk measures facilitate further analysis on insurers' risk-taking behavior and risk management strategies.

In the following paragraph we discuss existing measures for asset risk. Next, we discuss organizational form and group affiliation, factors related to strategic risk.

There are two existing methods to proxy asset risk. One is exposure oriented, the other one is market risk oriented. The exposure oriented method is based on the risk-based capital rule for financial industries. Specifically, it assigns penalty weights to

[24] Data source is NAIC life insurer's annual filing, and numbers are in book value.

different classes of assets in the asset portfolio. If the majority of an asset portfolio is invested in low-quality risky assets, the asset risk will be high. The exposure oriented method focuses on the allocation of the asset portfolio. In the banking industry, Shrieves and Dahl (1992), Berger (1995) and Jacques and Nigro (1997) used this method to proxy asset risk. In the insurance industry, Baranoff and Sager (2002 and 2003), Baranoff, Papadopoulos and Sager (2007) applied this method to the life insurance industry. One disadvantage of the exposure oriented method is its temporal inflexibility, for the weighting formula is fixed and time-invariant inherited from the fixed risk-based capital weights. As the relative risks of the various asset classes change in the market, the weights remain the same. The market risk oriented method overcomes that particular weakness. Baranoff, Papadopoulos and Sager (2007) introduced a market risk oriented method to proxy life insurers' asset risk, which they called the opportunity asset risk (OAR). Like asset risk in finance, their method measures asset risk by volatility of portfolio return. Since the actual returns of the life insurer portfolio are not available, they used an appropriate corresponding market index return to proxy the life insurer return for each asset class as a whole. In each month, the return of each asset class is computed by multiplying the corresponding market index returns for each asset class by the initial asset value of each asset class. Then the asset portfolio return is calculated as the sum of asset returns of all asset classes. This computation is performed for each of the twelve months of each year. OAR for a year is then computed as the standard deviation of the twelve months' returns in that year. As we mentioned already, this methodology partially overcomes the mark-to-market issue of insurers' asset by using up-to-date market indices.[25] More importantly, it updates asset risk with timely market change information, which captures the asset risk dynamics better.

Stock and mutual are the two most common organizational forms for insurance companies. In a stock insurance company, there are three major stakeholders in the firm: policyholders, owners, and managers.[26] For mutual insurers, there are only two major stakeholders, policyholders/owners and managers. A difference in organizational form could affect insurers' business strategy decisions and strategic risk for the following possible reasons. First, mutual insurers have less supervision or control over managers than stock insurers, and less control might encourage managers to exercise managerial discretion more in their own interests. Managerial discretion is a type of agency cost introduced by Jensen and Meckling (1976). Mayers and Smith (1982 and 1987) found that mutual insurers are more successful in lines of business requiring less managerial discretion, such as standardized products, whereas stock insurers are more successful in more risky or individualized products. Mutual insurers are owned by diversified policyholders and the control rights over the management team are not as strong as stock insurers. So managers of mutual insurers have more opportunities for managerial discretion. However, standardized or less risky products could limit managerial discretion, which can relieve this problem for mutual insurers. Second, stock insurers might have more financing channels than mutual insurers, which might also affect the cost of capital.

[25] Market value of asset is only required to be reported for stock insurers.
[26] The relationship between policyholders and equity holders in stock insurance companies are similar to bond holders and equity holders in a non-financial firm. Equity holders only have the right of residual claimant.

For example, public insurers can simply raise funds by issuing equities. Different means of financing will affect insurers' business strategies and strategic risks.

Whether an insurer is affiliated with the other insurers or whether an insurer is a group member of an insurance group or insurance holding company also affects strategic risk. As a group member, an insurer can take advantage of the greater access to financing resources of the group, more distribution channels or networking in bigger geographical areas and spillover benefit of group reputation. Financing resources within an insurance group or insurance holding company is called internal capital market, which is a topic in conglomerate firms study in finance. Empirical research has not confirmed the effect of internal market on conglomerate firms' investment strategies even though the internal market does exist. In insurance industries, Powell, Sommer and Eckles (2008) studied internal capital market activities in the property liability insurance industry. They found that internal capital market affected investment behavior of affiliated insurers.

1.2.2 Life Insurers' Enterprise Risks

Features of Life Insurers' Enterprise Risks

We have discussed some of insurers' major enterprise risks and presented some proxies. In this section, we apply those proxies to insurer data to begin our empirical analysis.

To study life insurers' asset risk, we first examine life insurers' asset allocation. Figure 1.2 displays life insurers' asset allocation in 16 asset classes in 2008. The percentage of each asset type is calculated as the total amount of investment in a certain type of asset for the entire life insurance industry, divided by total invested assets of the entire life insurance industry in each year. More than 50% of invested assets were in high quality corporate bonds, whereas stocks (both common and preferred) accounted for only 5.77%. Table 1.5 records life insurers' asset allocation in each of the 16 asset classes from 2005 to 2008.

Figure 1.2 Life Insurers' Invested Asset Portfolio Allocation in 2008

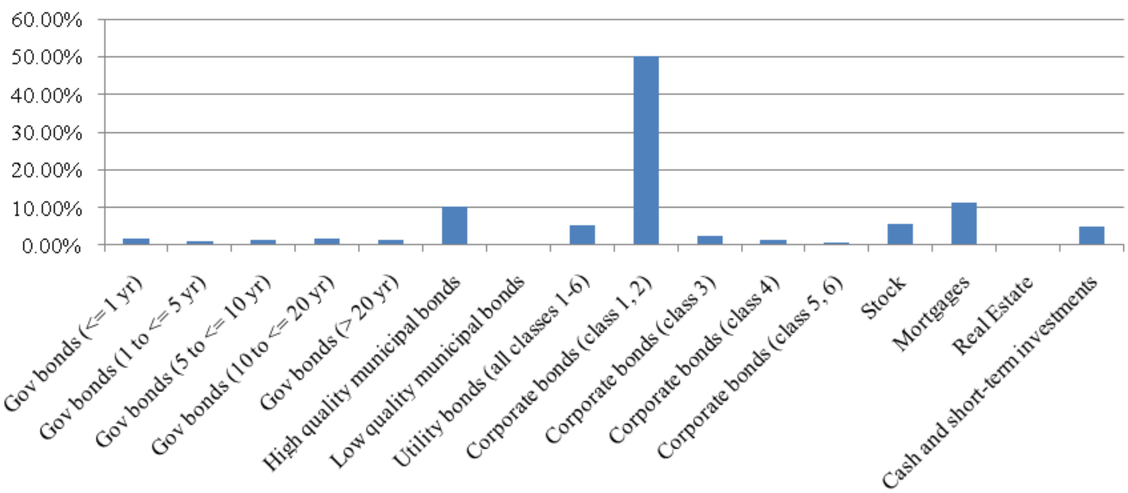


Table 1.5 Life Insurers' Invested Asset Portfolio Allocation 2005 - 2008

	2005	2006	2007	2008
Government bonds (<= 1 year)	$17,382,079,944	$21,245,497,300	$18,974,250,835	$48,852,301,468
Government bonds (1 to <= 5 year)	$40,695,893,677	$37,481,406,031	$29,878,239,324	$33,079,559,090
Government bonds (5 to <= 10 year)	$52,473,082,188	$42,642,409,833	$32,906,054,077	$36,599,713,765
Government bonds (10 to <= 20 year)	$49,798,980,709	$45,455,080,797	$47,077,010,937	$47,458,342,304
Government bonds (> 20 year)	$39,433,281,181	$38,408,307,783	$38,033,440,597	$45,678,417,053
High quality municipal bonds	$297,846,955,543	$298,643,190,551	$287,429,426,024	$294,823,481,563
Low quality municipal bonds	$140,926,142	$81,025,634	$170,634,303	$361,489,661
Utility bonds (all classes 1-6)	$145,651,586,918	$144,799,032,862	$145,301,910,758	$157,516,755,112
Corporate bonds (class 1, 2)	$1,433,816,600,000	$1,451,829,400,000	$1,509,360,500,000	$1,472,778,800,000
Corporate bonds (class 3)	$65,036,773,279	$59,525,273,385	$64,019,575,467	$72,963,355,313
Corporate bonds (class 4)	$33,889,492,678	$38,873,220,888	$35,766,014,036	$36,928,042,471
Corporate bonds (class 5, 6)	$10,665,182,029	$9,443,853,395	$13,587,124,328	$21,606,912,319
Stock	$150,835,106,762	$196,775,887,624	$200,593,517,076	$168,826,820,623
Mortgages	$276,462,626,485	$293,976,121,104	$315,053,282,265	$328,011,067,462
Real Estate	$13,735,125,434	$13,063,028,038	$13,678,159,512	$14,139,409,800
Cash and short-term investments	$60,987,957,911	$79,620,660,589	$78,954,937,437	$146,811,308,717
Cash and total invested assets	**$2,688,851,650,880**	**$2,771,863,395,814**	**$2,830,784,076,976**	**$2,926,435,776,721**

Using the asset risk proxy method described in the previous section, we calculated opportunity asset risk (OAR) for each life insurer. Table 1.6 presents summary statistics for OAR scaled by total assets of each insurer. We can see that life insurers' asset risks jumped in 2008 both in magnitude and standard deviation. It shows that OAR is a powerful measure to capture market risk of insurers' asset portfolios.

Table 1.6 Life Insurers' OAR Scaled by Invested Assets

	P1	**Median**	**P3**	**Mean**	**Stdev**
2005	0.0017	0.0019	0.0033	0.0030	0.0027
2006	0.0019	0.0021	0.0023	0.0026	0.0020
2007	0.0017	0.0025	0.0046	0.0039	0.0040
2008	0.0028	0.0037	0.0055	0.0059	0.0078

Examining life insurers' organizational forms and in-group status, we found that the majority of life insurers are formed as stock insurers. Also, most of them are members of affiliated groups. Table 1.7 summarizes these two proxies for the whole industry from 2005 to 2008.

Table 1.7 Life Insurers' Organizational Form and In Group Status

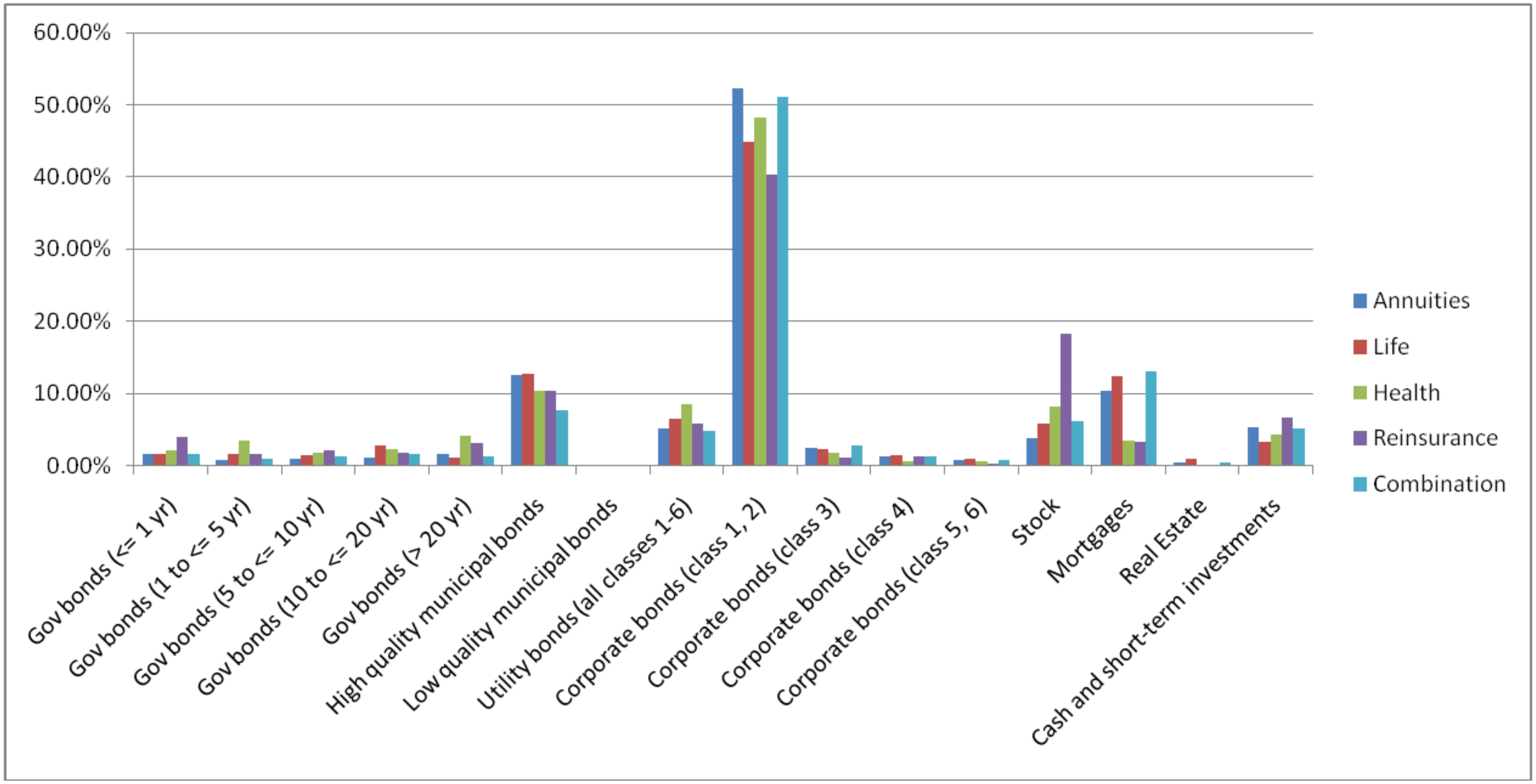
	N	**Stock Insurers**	**Group Members**
2005	941	868	706
2006	905	836	679
2007	853	792	637
2008	884	821	652

Life Insurers' Enterprise Risks and Product Types

In the product risk section, we discussed life insurers' major lines of business (life insurance, annuities, health insurance, and reinsurance) and the inherent differences in the underlying risk levels of these lines. In the life insurance literature, Baranoff and Sager (2003) introduced the business strategy hypothesis, which treats product specialization or choice of product mix as a predeterminant of other major business decisions, including other enterprise risks. It is reasonable that product risk should interact with the other enterprise risks. So we would like to examine whether the enterprise risks as proxied indeed vary with product specialization. Following Baranoff and Sager (2003), we classify each individual insurer as one of five types of insurers: annuities specialized, life insurance specialized, health insurance specialized, reinsurance specialized, and combination insurers. For each insurer, we calculate the proportion of total premiums obtained from each of the four lines of business (life insurance, annuities, health insurance, and reinsurance) and classify an insurer as a product specialist if more than 70% of its premiums are obtained from one line. For instance, if a life insurer has more than 70% of its premium writings from annuities, this life insurer is classified as annuities specialized. For insurers not specialized in any product type, we classify them into the combination group. In this way, we created five specialized groups and an insurer's group identity might change from year to year depending on its major premium writing resource. Then we examine enterprise risk proxies again for each group in each year.

First, we inspect life insurers' asset allocation. Figure 1.3 on the following page shows asset allocation for the five specialized groups. From this graph, life insurers with different product specializations do not show substantial difference on asset allocation. Reinsurance specialized insurers allocated more in stocks. Health and reinsurance specialized insurers hold less mortgages.

Figure 1.3 Life Insurers' Invested Asset Portfolio Allocation by Product Specialization in 2008



For each product specialized group, we calculated summary statistics for the asset risk proxy OAR scaled by total assets. Table 1.8 shows the summary statistic for all five groups from 2005 to 2008. Reinsurance specialized insurers have the highest asset risk throughout years, while annuities specialized insurers maintain the lowest asset risk. Life and health specialized insurers have medium asset risk. And asset risks go up in 2008 for all groups.

Table 1.8 Life Insurers' OAR Scaled by Invested Assets by Products

	Annuities				**Life**		
	Median	**Mean**	**Stdev**		**Median**	**Mean**	**Stdev**
2005	0.0017	0.0020	0.0017	**2005**	0.0020	0.0032	0.0030
2006	0.0020	0.0020	0.0003	**2006**	0.0020	0.0025	0.0021
2007	0.0018	0.0025	0.0030	**2007**	0.0027	0.0040	0.0038
2008	0.0033	0.0040	0.0058	**2008**	0.0036	0.0057	0.0076

	Health				**Reinsurance**		
	Median	**Mean**	**Stdev**		**Median**	**Mean**	**Stdev**
2005	0.0023	0.0030	0.0022	**2005**	0.0029	0.0044	0.0041
2006	0.0022	0.0025	0.0017	**2006**	0.0022	0.0035	0.0035
2007	0.0028	0.0037	0.0032	**2007**	0.0040	0.0060	0.0064
2008	0.0042	0.0055	0.0060	**2008**	0.0044	0.0097	0.0144

	Combination		
	Median	**Mean**	**Stdev**
2005	0.0019	0.0027	0.0020
2006	0.0021	0.0024	0.0014
2007	0.0025	0.0037	0.0036
2008	0.0033	0.0054	0.0059

We also compare organizational form and group affiliation of insurers in different product specialization and results are in Table 1.9. For all product specialization groups, majority of insurers are stock insurers and have some group affiliation. Reinsurance specialized insurers are almost all stock insurers.

Table 1.9 Life Insurers' Organizational Form and In Group Status by Products

	Annuities		
	N	**Stock**	**Group**
2005	106	99	95
2006	97	91	87
2007	84	79	77
2008*	96	90	84

	Life		
	N	**Stock**	**Group**
2005	269	245	178
2006	256	238	172
2007	247	230	163
2008*	237	220	156

	Health		
	N	**Stock**	**Group**
2005	185	168	144
2006	180	163	140
2007	174	164	136
2008*	172	160	136

	Reinsurance		
	N	**Stock**	**Group**
2005	104	104	71
2006	105	105	69
2007	94	94	62
2008*	92	91	61

	Combination		
	N	**Stock**	**Group**
2005	277	252	218
2006	267	239	211
2007	254	225	119
2008*	226	203	178

* In 2008, 61 firms had 0 or negative premium writings, and they are left out this counting.

1.2.3 Health Insurers' Enterprise Risks

U.S. Healthcare Delivery System

In the U.S. healthcare delivery system, health insurers are financial intermediaries. Money flows from consumers/patients/employers to health care providers through health insurers. As a result, health insurers have developed a role as managers of access to health care through their ability to approve or to disapprove payment for services. Health insurers take a variety of organizational structures: profit and non-profit; mutual and stock (most of which are not publicly traded), as well as Blue Cross and Blue Shield (BC/BS). Also, the healthcare delivery system is characterized by managed care, which was designed to save medical expenses. HMO, PPO and POS are popular networks and organizations that deliver healthcare and medical services through managed care.[27] In HMO networks, subscribers have greater restrictions on their choices of providers and services than in other arrangements and patients need primary care physicians' reference to see specialists (gatekeeper). On the other hand, PPO networks provide flexible choices regarding providers and medical services and there is no gatekeeper. Therefore, PPO plans are usually more expensive for consumers than HMO plans.

Before the Patient Protection and Affordable Care Act (PPACA) of 2010, the evolution of the U.S. health care system excluded more than 50 million Americans from coverage for various reasons.[28] The excluded group has not been part of the managed care system

[27] HMO: Health Maintenance Organization; PPO: Preferred Provider Organization; POS: Point of Service, can be either HMO or PPO.

[28] By the end of 2009, there were 50.7 million uninsured people in the U.S. Income, Poverty and Health Insurance Coverage in the United States 2009, US Census of Bureau, September 2010

and has used the health care system mostly on an emergency basis without discounts. Traditionally, U.S. regulation of insurers has been in the domain of the states, rather than the Federal government. State regulation has emphasized insurer solvency and consumer protection and arranged for guarantee funds, which provide payment for the claims of insolvent insurers. Reimbursement limits for guarantee funds are set by each state and vary from $100,000 to $500,000 per claimant.[29]

PPACA brings the uninsured population into the system and the Federal government plays a larger regulatory and participatory role. The states still regulate the health insurance industry within the requirements of the new law (yet to be completely clarified).[30] The consumer group grows with the addition of the formerly uninsured. Persons with pre-existing conditions are expected to flow into high risk pools subsidized by the Federal government and implemented by the states and the Federal government. Since PPACA mandates coverage for all, Exchanges are planned to insure persons otherwise lacking easy access to the system. Under PPACA, the health insurance industry retains its position as financial intermediary and the "holder" of the managed care methods for utilization and apportionment of claims payments.

[29] See "NOLHGA, the Life and Health Insurance Guaranty System, and the Financial Crisis of 2008-2009" by Peter G. Gallanis, June 5, NY, NY at the American Bar Association Tort Trial & Insurance Practice Session.
[30] The detailed implementation of PPACA evolves daily, and is not discussed here.

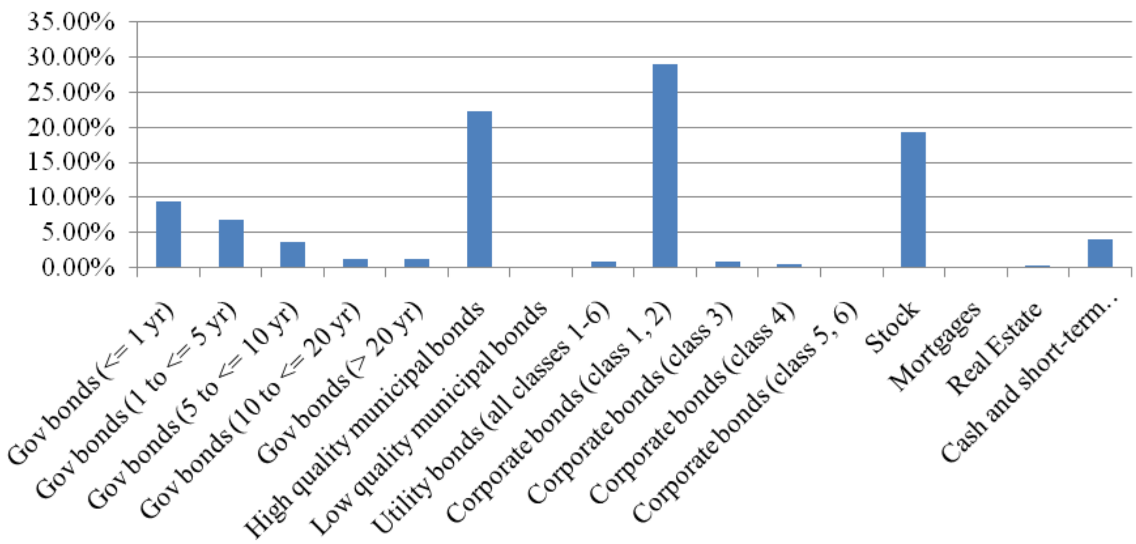
Features of Health Insurers' Enterprise Risks

Like other insurers, health insurers need to manage product risk and asset risk under different organizational forms. However, health insurers' enterprise risks have some distinctive attributes because health insurers are underwriting highly risky health insurance products in the complex healthcare delivery system. First, health insurers need to have good control over their asset risk. On the one hand, a high level of product risk may put more pressure on health insurers' asset risk management. On the other hand, health insurers need to make payments to healthcare providers once medical services are provided. For this purpose, health insurers have a high volume of cash flows in and out. Therefore, high quality liquid assets compose a major part of health insurers' asset portfolios. Second, health insurers manage the majority of health insurance policies through managed care. From the most restrictive HMO to the most flexible PPO, different managed care networks actually carry different levels of risk to health insurers. With more restriction and control over medical services provided, HMO type plans eliminate more uncertainties in the insurance contract and thereby reduce health insurers' loss exposures. On the other hand, PPO type plans keep more uncertainties by providing more flexibility to policyholders, which increases insurers' loss exposures.

In the following, we will first examine health insurers' asset risks, organizational forms, group affiliations, and managed care networks or plan types. Then we will inspect different asset risks, organizational forms, and group affiliation status for different groups of insurers focusing on certain managed care networks. Finally we will check the same set of risk proxies further for different groups of insurers focusing on different health insurer products.

Figure 1.4 displays health insurers' collective invested asset allocation in 2008. Compared with Figure 1.2 (life insurers' collective invested asset allocation in 2008), Figure 1.4 shows that health insurers hold relatively more high quality instruments and more liquid instruments. They hold almost no mortgage and real estate and about half of the government bonds in the portfolio have less than one year maturity. The asset allocation profile matches features of health insurers' businesses as we discussed above.

Figure 1.4 Health Insurers' Invested Asset Portfolio Allocation in 2008



OAR (opportunity asset risk – a volatility-based asset risk measure) scaled by total invested assets is shown in Table 1.10. We do not see much variation in OAR from year to year even during the financial crisis of 2008.

Table 1.10 Health Insurers' OAR Scaled by Total Invested Assets 2005 – 2008

	P1	Median	P3	Mean	Stdev
2005	0.0019	0.0026	0.0056	0.0046	0.0050
2006	0.0021	0.0029	0.0052	0.0043	0.0045
2007	0.0022	0.0037	0.0054	0.0046	0.0046
2008	0.0023	0.0035	0.0055	0.0045	0.0037

Table 1.11 shows health insurers' organizational forms and group affiliations. The majority of health insurers are still organized as stock insurers and have certain group affiliations, but the percentage is not as high as life insurers shown in table 1.7.

Table 1.11 Health Insurers' Organizational Form and In Group Status

	N	Stock Insurers	Group Members
2005	828	607	555
2006	876	645	585
2007	870	640	586
2008	881	654	613

Each health insurance contract comes with a specific plan type. Table 1.12 shows covered members in each type of plan from 2005 to 2008. Membership in HMO plans decreased, while membership in PPO plans increased. HMO and PPO plans account for the majority of health insurance contracts. Indemnity plans, which are just the traditional fee-for-service type contracts instead of managed care plans, decreased as well.

Table 1.12 Insured Members by Plan Type*

	2005	2006	2007	2008
HMO	51,348,071	50,934,052	43,557,962	40,965,478
PPO	33,191,355	35,917,900	39,970,165	41,610,224
POS	11,014,824	10,787,754	9,221,476	9,691,149
PSO	2,277,637	1,781,108	527,325	294,200
Indemnity	16,498,885	17,946,390	15,479,747	14,434,015

* HMO: Health Maintenance Organization;
PPO: Preferred Provider Organization;
POS: Point of Service (HMO or PPO);
PSO: Patient Safety Organization;
Indemnity: Fee for Service

Health Insurers' Enterprise Risks and Plan Type

As we discussed previously, different plan types may contribute to riskiness of health insurance contracts. We wonder whether insurers' maintain certain asset risks in response to plan types. Specifically, we classify each insurer into different plan type concentration groups. For example, if the majority (here we use the cutoff point of 70%) of an insurer's plans are HMO plans, then we classify this insurer as HMO concentrated. If an insurer has none of the plan types above 70%, we classify this insurer as combination type. Then we study asset risk, organizational form and group affiliation for various plan concentration groups.

Figure 1.5 displays the asset allocations of different plan concentration groups. The percentage of each asset class is calculated as total amount invested in the specific asset class divided by total invested assets for each plan concentration group as an aggregate. Figure 1.5 shows that asset portfolio allocations across groups resemble Figure 1.3. The indemnity group is highly invested in stocks in 2008. PPO, PSO and Indemnity groups experienced negative cash flow in 2008. HMO groups held the highest weight of cash compared with the other groups.

Figure 1.5 Health Insurers' Invested Asset Portfolio Allocation by Plan Type in 2008

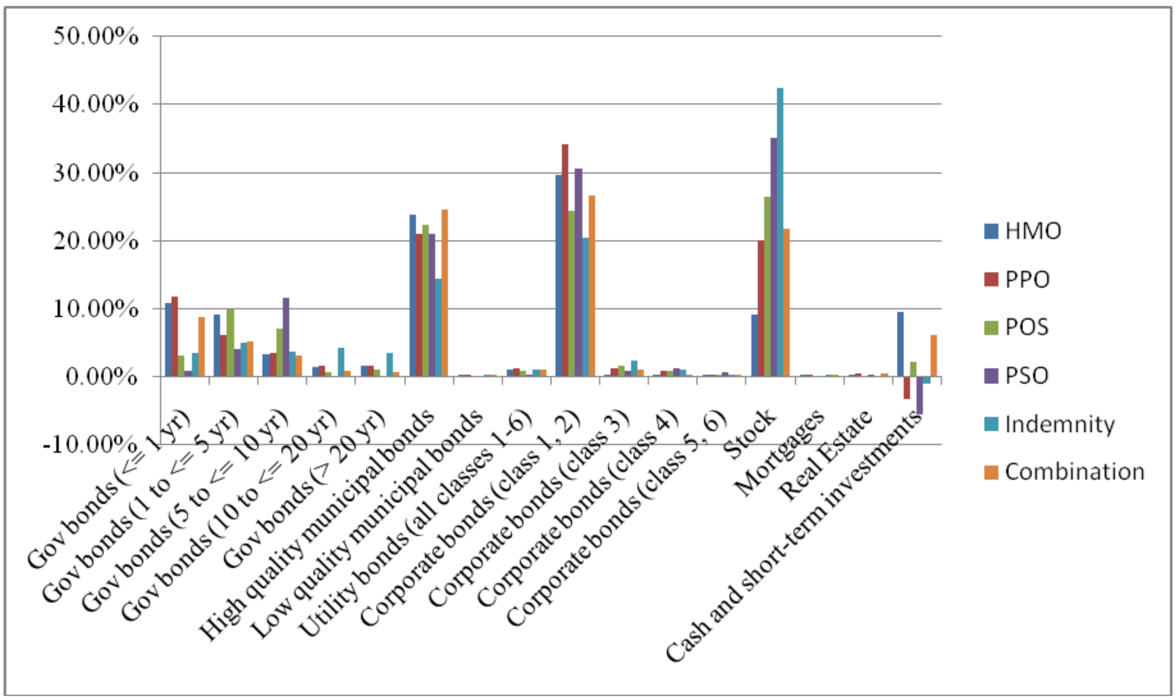


Table 1.13 presents asset risk proxy OAR scaled by invested assets for different plan groups. The HMO concentrated group maintains the lowest asset risk, whereas the Indemnity group has the highest asset risk and the PPO group has the second highest

asset risk. Interestingly, asset risk across groups decreased in 2008 for all groups except for HMO group.

Table 1.13 Health Insurers' OAR Scaled by Invested Assets by Plan Type

	HMO				PPO		
	Median	**Mean**	**Stdev**		**Median**	**Mean**	**Stdev**
2005	0.0024	0.0039	0.0048	**2005**	0.0042	0.0058	0.0047
2006	0.0026	0.0035	0.0031	**2006**	0.0046	0.0059	0.0057
2007	0.0032	0.0038	0.0026	**2007**	0.0047	0.0063	0.0063
2008	0.0029	0.0041	0.0032	**2008**	0.0040	0.0054	0.0043

	POS				PSO		
	Median	**Mean**	**Stdev**		**Median**	**Mean**	**Stdev**
2005	0.0029	0.0053	0.0059	**2005**	0.0051	0.0055	0.0049
2006	0.0034	0.0045	0.0043	**2006**	0.0056	0.0051	0.0034
2007	0.0033	0.0045	0.0039	**2007**	0.0066	0.0135	0.0179
2008	0.0026	0.0033	0.0019	**2008**	0.0063	0.0071	0.0076

	Indemnity				Combination		
	Median	**Mean**	**Stdev**		**Median**	**Mean**	**Stdev**
2005	0.0053	0.0074	0.0067	**2005**	0.0030	0.0052	0.0051
2006	0.0054	0.0073	0.0079	**2006**	0.0037	0.0052	0.0049
2007	0.0046	0.0056	0.0044	**2007**	0.0044	0.0054	0.0055
2008	0.0039	0.0058	0.0047	**2008**	0.0035	0.0047	0.0039

Table 1.14 shows the number of insurers in each plan concentration group, organizational form and group affiliation. The majority of insurers are in HMO plan groups. Most of health insurers are stock insurers and are group members.

Table 1.14 Health Insurers' Organizational Form and In Group Status by Plan Type*

	HMO				PPO		
	N	**Stock**	**Group**		**N**	**Stock**	**Group**
2005	425	351	300	**2005**	69	37	47
2006	436	353	304	**2006**	76	37	48
2007	407	328	281	**2007**	87	50	60
2008	419	338	294	**2008**	85	49	60

	POS				PSO		
	N	**Stock**	**Group**		**N**	**Stock**	**Group**
2005	33	24	20	**2005**	10	6	2
2006	30	23	19	**2006**	8	4	3
2007	27	21	16	**2007**	9	6	4
2008	29	23	17	**2008**	8	6	3

	Indemnity				Combination		
	N	**Stock**	**Group**		**N**	**Stock**	**Group**
2005	23	11	12	**2005**	203	131	140
2006	28	15	15	**2006**	206	131	140
2007	23	13	13	**2007**	218	134	153
2008	24	12	15	**2008**	218	142	157

* Some insurers did not report plan types in certain years. There are 65, 92, 99, and 98 such insurers in 2005 to 2008.

Health Insurers’ Enterprise Risks and Product Types

In the product risk section, we analyzed risk levels of health insurers’ products. We considered the variation of asset risk, organizational form and group affiliation of health insurers by product specializations. Paralleling our partitioning of the life insurance industry by product specialization, we now partition health insurers by product specialization based upon the percentage of premium income in each line of business or product. We again use 70% as the cutoff point for assignment to product specialization.[31]

Figure 1.6 displays asset allocation by product specialization for health insurers in 2008. Vision specialized insurers have made the greatest investment in stocks in 2008 and their cash flow and short-term investments ended up to be negative.[32]

[31] The number of insurers included in each product specialization group can be found in table 16.

[32] A number of large insurers specialized in vision experienced negative cash and short-term investment in accounting in 2008. Those insurers have a large exposure in stock investment.

Figure 1.6 Health Insurers' Invested Asset Portfolio Asset Allocation by Product Specialization in 2008

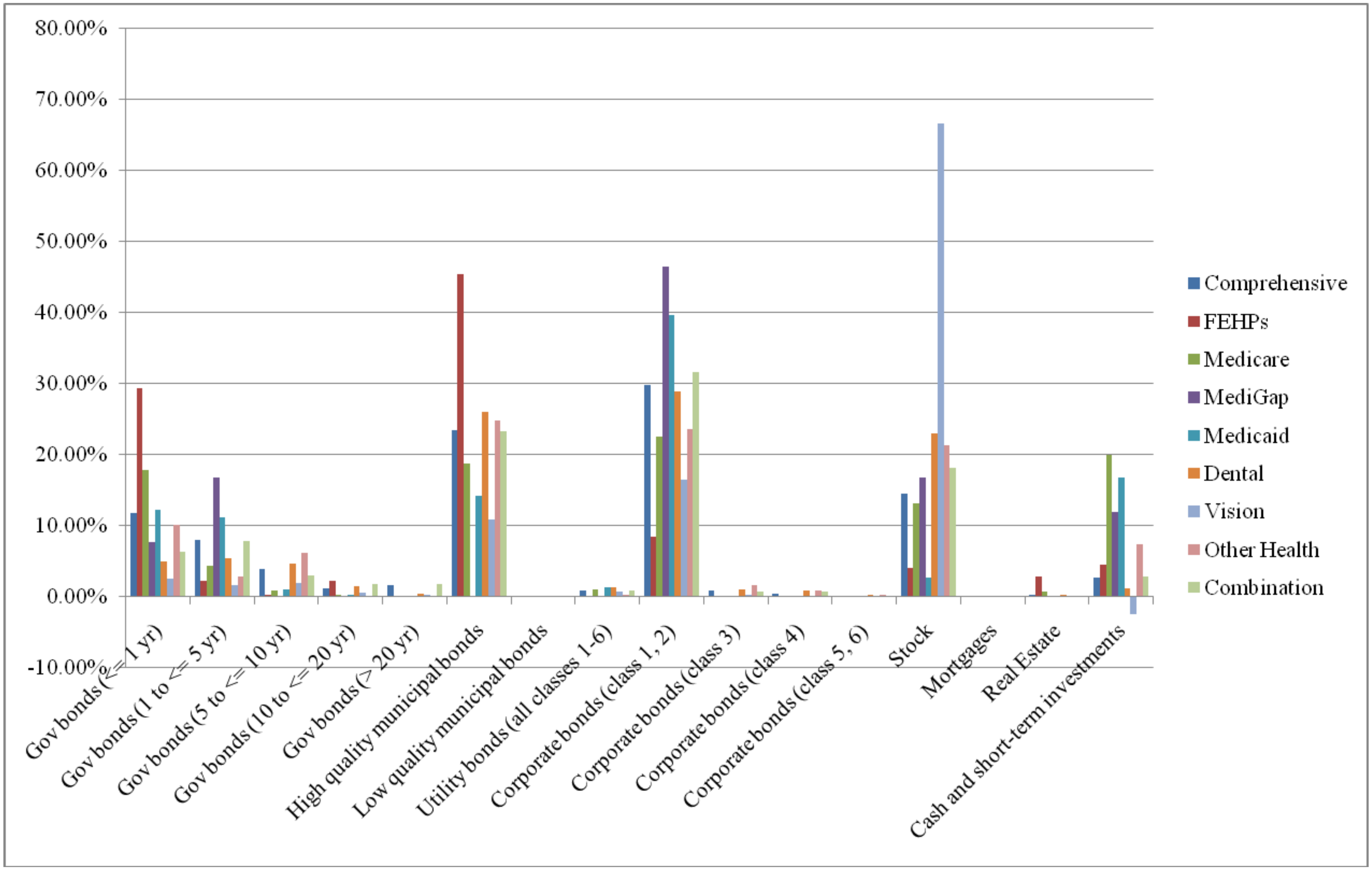


Table 1.15 shows calculated OAR scaled by invested assets as the asset risk measure for different product specialization groups. Medicare and MediGap groups and other health product groups (Disability, Prescription Drug, and Long Term Care) have comparatively larger asset risks.

Table 1.15 Health Insurers' OAR Scaled by Invested Assets by Product Specialization

	Combination			Comprehensive & FEHPs*		
	Median	**Mean**	**Stdev**	**Median**	**Mean**	**Stdev**
2005	0.0024	0.0045	0.0048	0.0027	0.0049	0.0051
2006	0.0032	0.0039	0.0025	0.0029	0.0049	0.0052
2007	0.0028	0.0035	0.0023	0.0035	0.0047	0.0043
2008	0.0025	0.0036	0.0041	0.0028	0.0043	0.0034

	Dental			Medicaid		
	Median	**Mean**	**Stdev**	**Median**	**Mean**	**Stdev**
2005	0.0026	0.0045	0.0052	0.0026	0.0037	0.0032
2006	0.0029	0.0042	0.0051	0.0029	0.0039	0.0039
2007	0.0042	0.0048	0.0043	0.0037	0.0041	0.0031
2008	0.0040	0.0046	0.0035	0.0043	0.0046	0.0031

	Medicare & MediGap**			Other Health		
	Median	**Mean**	**Stdev**	**Median**	**Mean**	**Stdev**
2005	0.0034	0.0051	0.0083	0.0049	0.0043	0.0021
2006	0.0025	0.0035	0.0030	0.0031	0.0046	0.0038
2007	0.0040	0.0052	0.0074	0.0051	0.0051	0.0030
2008	0.0052	0.0054	0.0039	0.0053	0.0060	0.0055

	Vision		
	Median	**Mean**	**Stdev**
2005	0.0024	0.0038	0.0030
2006	0.0048	0.0048	0.0028
2007	0.0050	0.0056	0.0059
2008	0.0040	0.0042	0.0022

* Comprehensive and FEHPs are combined as one type of product type since there are only a few insurers specialized in FEHPs. **Medicare and MediGap are combined as one type of product since there are only a couple of insurers specialized in MediGap.

Table 1.16 displays health insurers' organizational forms and group affiliations by product specializations. More insurers are in Medicare and MediGap specialized group in recent years. Almost all product specialization groups have the majority of insurers as stock insurers except the vision specialized group.

Table 1.16 Health Insurers' Organizational Form and In Group Status by Product Specialization*

	Combination			Comprehensive & FEHPs		
	N	Stock	Group	N	Stock	Group
2005	93	73	62	346	244	269
2006	84	64	57	365	255	281
2007	78	56	53	340	234	261
2008	88	64	63	325	226	250

	Dental			Medicaid		
	N	Stock	Group	N	Stock	Group
2005	149	113	81	88	70	54
2006	148	111	87	87	66	56
2007	148	110	91	88	67	61
2008	143	107	89	91	70	62

	Medicare & MediGap			Other Health		
	N	Stock	Group	N	Stock	Group
2005	47	42	30	15	10	8
2006	51	44	28	24	14	9
2007	66	60	33	30	21	13
2008	93	85	58	27	18	13

	Vision		
	N	Stock	Group
2005	27	13	17
2006	30	16	16
2007	28	13	17
2008	26	11	15

* There are some insurers with 0 or negative premium income in each year. They are excluded from these tallies. They number 63, 87, 92, and 88 from year 2005 to 2008.

1.3 Insurers' Risk Management by Capital and Hedging

1.3.1 Insurers' Risk Management Tools

Reinsurance, derivative hedging and capital are some of insurers' major risk management tools. Reinsurance and derivative hedging are risk reduction tools, while capital is a risk mitigation tool and it is usually used as a resort to buffer unexpected losses caused by insurers' underwriting or asset management. Here, we focus on capital and derivative hedging.

"Reinsurance is a contractual agreement under which an insurer secures coverage from a reinsurer for a potential loss to which it is exposed under insurance policies issued to original insureds." [33] Essentially, reinsurance is insuring insurance contracts. Reinsurance is a longstanding and common risk reduction practice for insurers. [34] However, in recent years, reinsurance business in the U.S. has been declining in the life insurance industry.[35]

On the other hand, derivatives hedging have become more popular. By the end of 2010, the notional amount of over-the-counter derivatives held by the insurance industry totaled $850.4 billion [36]. Life insurers are primary users of derivative instruments, representing 93.4% of the total notional amount for the whole insurance industry

[33] "Understanding Reinsurance", David M. Rain and Joy L. Langford, New Appleman Insurance Law Practice Guide, Mathew Bender & Company 2007.

[34] In fact the first independent professional reinsurance company, Cologne Re. was founded in 1842. "A Brief History of Reinsurance", David M. Holland, Reinsurance News, February 2009, Issue 65.

[35] In life reinsurance business, U.S. recurring life reinsurance ceded fell again from $724.2 billion in 2006 to $682.9 billion in 2007. Life Reinsurance Data from the Munich American Survey, David M. Bruggeman, Reinsurance News, August 2008, Issue No. 63.

[36] According to the definition of Chicago Mercentile Exchange (CME) group, 'notional value' refers to the underlying value (face value) of the financial instrument or commodity specified in a futures or options on a futures contract.

including life/health, property-liability and health insurance industries.[37] Indeed, derivative instruments are more versatile and flexible risk management tools compared to reinsurance especially for life insurers. Life insurers can use derivatives to hedge various financial risks directly or create synthetic asset.[38] More importantly, derivative hedging is a critical tool for life insurers to hedge financial risk exposure caused by guarantees of VAGB products when reinsurance capacity dries up. In fact, hedging programs saved the industry about $40 billion during the rapid equity market declines of September and October of 2008.[39]

Insurers are required to hold a certain amount of capital. Capital is insurers' first immediate resort when reserves fail to meet claims. The NAIC specifies the minimum amount (authorized control level) of capital that insurers must hold for the insurers' level of asset risk, underwriting risk and business risk. This minimum is known as the risk-based capital (RBC).[40] However, prudent insurers usually keep much higher levels of capital than the RBC requirement. Reasons include the cost of financial distress, the high cost of refinancing and financial ratings concerns, which we will discuss in detail in the following literature review section. In fact, not only is the absolute value of capital important to insurers, but also the ratio of insurers' capital to total assets – a ratio known as the capital ratio in the insurance industry. The capital ratio of insurers resembles the leverage or capital structure of firms in nonfinancial industries.

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[37] 'Weekly Special Report of the NAIC's Capital Market Bureau', NAIC & Center for Insurance Policy and Research

[38] Synthetic asset is to take various positions to create the same effect as holding a certain asset or investment vehicle. For instance, life insurers use treasuries and credit default SWAP to replicate corporate bonds.

[39] 'Responding to the Variable Annuity Crisis', McKinsey Working Papers on Risk, McKinsey & Company, November 2010

[40] 'Risk-Based Capital General Overview', NAIC, July 15 2009

Even though reinsurance is an important method by which insurers transfer or manage risks, we focus on risk management by hedging and capital in this dissertation since one of our primary purposes is to inspect how insurers manage product risk, asset risk and the other enterprise risks using capital. Also, a number of life insurers rely on derivative instruments to hedge the new product risk created by guarantees for variable annuities. A major part of this dissertation is devoted to identifying and quantifying this new product risk and to examining how life insurers manage it. In the next section, we examine capital ratio and derivative applications for life and health insurers separately.

Life Insurers' Capital and Derivatives Activities

First we examine the capital ratio and derivatives activities for the whole life insurance industry. Table 1.17 presents summary statistics of life insurers' capital ratios from 2005 – 2008. Life insurers' mean and median capital ratio is stable across these years. Median capital ratio is consistently less than mean capital ratio, and the distribution of capital ratio is skewed to the right.

Table 1.17 Life Insurers' Capital Ratio 2005 - 2008*

Year	P1	Median	P3	Mean	Stdev
2005	0.087	0.201	0.492	0.312	0.277
2006	0.088	0.202	0.491	0.315	0.281
2007	0.089	0.203	0.483	0.314	0.281
2008	0.085	0.205	0.540	0.340	0.310

* Insurers with capital ratio below 0 or above 1 are excluded.

Table 1.18 lists the number of insurers in the life insurance industry (the number that report to the NAIC in the Life category) and number of life insurers active in derivative applications as of the year-end. The total number of life insurers decreased from 2005 to 2008. The number of insurers with active derivatives transactions also decreased.

Table 1.18 Number of Life Insurers Active in Derivatives

	2005	**2006**	**2007**	**2008**
# of Insurers	933	899	848	872
# of Insurers using Derivatives	166	164	164	161

To inspect the capital ratio and derivatives activity strategies of insurers with different product specializations, we again assign each insurer to one specific product specialization if the insurer's written premiums in a product type exceed 70% of total premiums. Table 1.19 shows capital ratio summary statistics for insurers with different product specializations. Annuity specialized insurers hold the minimum capital ratio throughout the years, while insurers specialized in reinsurance hold the highest capital ratio. Also, health insurance specialized insurers hold a high capital ratio. Table 1.20 shows the number of life insurers in each product specialization and the number of insurers active in derivative transactions in each product specialization group. The table shows that most derivative users are annuity specialized insurers. Health insurance specialized insurers are less likely to use derivatives.

Table 1.19 Life Insurers' Capital Ratio by Product Specialization

	Annuity			Combination		
	Median	Mean	Stdev	Median	Mean	Stdev
2005	0.063	0.115	0.174	0.164	0.273	0.250
2006	0.061	0.108	0.157	0.169	0.272	0.250
2007	0.057	0.124	0.193	0.164	0.274	0.251
2008	0.063	0.116	0.176	0.163	0.270	0.256

	Health			Life		
	Median	Mean	Stdev	Median	Mean	Stdev
2005	0.422	0.435	0.242	0.166	0.279	0.275
2006	0.388	0.403	0.232	0.165	0.299	0.288
2007	0.424	0.417	0.238	0.169	0.284	0.283
2008	0.428	0.415	0.237	0.148	0.289	0.297

	Reinsurance		
	Median	Mean	Stdev
2005	0.488	0.487	0.311
2006	0.523	0.504	0.337
2007	0.417	0.479	0.340
2008	0.424	0.473	0.338

Table 1.20 Number of Life Insurers Active in Derivatives by Product Specialization

Specialization		2005	2006	2007	2008*
Annuity	**# of Insurers**	106	96	84	96
	# of Insurers using Derivatives	49	52	47	52
Combination	**# of Insurers**	277	267	254	266
	# of Insurers using Derivatives	73	73	73	70
Health	**# of Insurers**	183	180	174	170
	# of Insurers using Derivatives	7	7	8	8
Life	**# of Insurers**	266	253	244	232
	# of Insurers using Derivatives	25	22	27	23
Reinsurance	**# of Insurers**	101	103	92	91
	# of Insurers using Derivatives	12	10	9	7

* There are 57 life insurers excluded since they experienced negative or zero premium written.

Health Insurers' Capital

For health insurers, we will study only capital as a risk management tool since very few health insurers are involved in derivative transactions. At the end of 2008, there were only 5 health insurers active in derivative transactions. First, we examine health insurers' capital ratio for the whole industry. Table 1.21 presents the summary statistics for health insurers with capital ratios between 0 and 1. Compared to life insurers' capital ratio (Table 1.17), health insurers hold relatively high capital ratios. High capital ratios are consistent with health insurers' business focus. Health insurance products are riskier than life and annuity products. Also, health insurers' cash flows move rapidly from policyholder to insurers to medical service providers.

Table 1.21 Health Insurers' Capital Ratio*

	N	**P1**	**Median**	**P3**	**Mean**	**Stdev**
2005	**821**	0.356	0.508	0.698	0.525	0.251
2006	**866**	0.388	0.533	0.729	0.548	0.255
2007	**864**	0.418	0.555	0.737	0.567	0.250
2008	**871**	0.401	0.570	0.753	0.569	0.256

* Insurers with capital ratio above 1 or less than 0 are excluded

Further, we also examine health insurers' capital ratio in regard to health insurer's product specializations and health insurance policy plan. Table 1.22 shows health insurers' capital ratio by product specialization. Among all health products, dental and vision specialized insurers hold the highest capital ratios, whereas Medicare and Medicaid groups hold the lowest. This result does not accord with our expectation, since dental and vision insurance contracts just provide partial coverage, which is subject to upper limits, thus limiting the risk of dental and vision specialized insurers.

Table 1.22 Health Insurers' Capital Ratio by Product Specialization*

Combination

Year	N	Median	Mean	Stdev
2005	93	0.396	0.407	0.155
2006	84	0.486	0.469	0.151
2007	78	0.516	0.505	0.155
2008	86	0.549	0.529	0.193

Comprehensive & FEHPs

Year	N	Median	Mean	Stdev
2005	344	0.497	0.497	0.198
2006	361	0.517	0.516	0.198
2007	338	0.523	0.525	0.184
2008	324	0.529	0.527	0.199

Dental

Year	N	Median	Mean	Stdev
2005	149	0.720	0.649	0.271
2006	147	0.724	0.651	0.276
2007	147	0.719	0.662	0.252
2008	143	0.745	0.680	0.251

Medicaid

Year	N	Median	Mean	Stdev
2005	88	0.363	0.374	0.171
2006	87	0.395	0.422	0.162
2007	88	0.451	0.435	0.174
2008	88	0.415	0.430	0.164

Medicare & MediGap

Year	N	Median	Mean	Stdev
2005	45	0.345	0.407	0.188
2006	48	0.394	0.375	0.224
2007	65	0.446	0.440	0.265
2008	90	0.471	0.487	0.254

Other Health Products

Year	N	Median	Mean	Stdev
2005	15	0.586	0.532	0.348
2006	24	0.478	0.442	0.324
2007	30	0.491	0.503	0.334
2008	27	0.449	0.468	0.333

Vision

Year	N	Median	Mean	Stdev
2005	27	0.797	0.707	0.250
2006	30	0.837	0.750	0.226
2007	28	0.826	0.753	0.209
2008	25	0.832	0.788	0.179

* In each year some insurers are excluded because they experience negative or zero premium income. Such exclusions number 60, 85 90, 88 in 2005 - 2008.

Table 1.23 shows health insurers' capital ratio by plan. Health insurers concentrated in indemnity plans hold about 0.1 higher capital ratios than other plans.

Table 1.23 Health Insurers' Capital Ratio by Plan Type*

Combination					HMO				
Year	**N**	**Median**	**Mean**	**Stdev**	**Year**	**N**	**Median**	**Mean**	**Stdev**
2005	202	0.521	0.534	0.255	**2005**	423	0.457	0.465	0.206
2006	204	0.560	0.568	0.255	**2006**	433	0.488	0.483	0.212
2007	216	0.572	0.577	0.245	**2007**	405	0.506	0.503	0.212
2008	217	0.598	0.593	0.243	**2008**	410	0.504	0.502	0.217
Indemnity					**POS**				
Year	**N**	**Median**	**Mean**	**Stdev**	**Year**	**N**	**Median**	**Mean**	**Stdev**
2005	23	0.666	0.656	0.181	**2005**	32	0.555	0.583	0.266
2006	28	0.670	0.600	0.262	**2006**	29	0.541	0.598	0.229
2007	23	0.646	0.666	0.245	**2007**	27	0.576	0.579	0.191
2008	24	0.665	0.616	0.244	**2008**	29	0.634	0.623	0.225
PPO					**PSO**				
Year	**N**	**Median**	**Mean**	**Stdev**	**Year**	**N**	**Median**	**Mean**	**Stdev**
2005	69	0.560	0.554	0.245	**2005**	10	0.359	0.447	0.352
2006	74	0.540	0.540	0.192	**2006**	8	0.322	0.380	0.331
2007	87	0.528	0.534	0.186	**2007**	9	0.646	0.535	0.342
2008	85	0.514	0.552	0.197	**2008**	8	0.745	0.603	0.391

* Some insurers are excluded since they did not report plan types. Such exclusions number 62, 90, 97, 98 in 2005 - 2008.

1.3.2 Literature Review on Risk Management by Capital and Derivative Hedging

Risk management is becoming an important field of corporate finance research. In classic finance theory, risk management is a deadweight loss because a corporation is held by diversified shareholders and shareholders can eliminate idiosyncratic risks by diversification of their own portfolios under the efficient and complete market. However, in the real world, financial markets are not frictionless or complete. Risk management is useful to control various frictions and thereby contributes to shareholders' value. From the corporate finance perspective, capital structure theories sit at the heart of modern corporate finance research. Capital structure theories under various real world frictions provide rationales of corporate risk management. Therefore, we will first overview capital structure theories, which actually lay out the foundation for further risk management research discussion. Then we will discuss incentives for corporate risk management. Later, we will cover empirical risk management research by using capital and hedging.

<u>Capital Structure Theories</u>

How to finance a firm, debt or equity? This question and related issues have been the center of attention in corporate finance research for decades. Miller and Modigliani (M&M 1958) first propounded the irrelevance of financing methods to a firm's total market value and cost of capital under perfect capital markets.[41] Perfect markets preclude

[41] Perfect Capital Market (PCM) refers to: agents are perfectly rational and pursue utility maximization; no direct transaction cost, regulation or taxes and all assets are perfectly divisible; perfect competition in

the existence of frictions. In reality, the frictionless world doesn't exist. Taxes, transaction or bankruptcy costs, agency costs and information asymmetry introduce frictions that affect firms' debt-equity decisions or capital structures. Therefore tradeoff, pecking order, agency theories, market timing, and inertia hypotheses were introduced to adapt M&M theory to the real world.[42] Harris and Raviv (1991) and Myers (2001) give extensive reviews of most of the major capital structure theories. With the assistance of comprehensive financial datasets, for instance COMPUSTAT, much empirical research has been done to test theories related to capital structure and its determinants.[43] Besides empirical research, Graham and Harvey (2001) conducted a survey on cost of capital, capital budgeting and capital structure decision-making for 392 CFOs and reported findings from real practices.

Empirical research highlights some determinants of capital structure. Harris and Raviv's (1991) summary identified several capital structure determinants in prior

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product and security markets; symmetric information and information is either certain or risky. Fisher, Irving (1930), *The Theory of Interest*, MacMillan, New York.

[42] *Tradeoff theory* aims at the balance between the tax savings and the cost of financial distress because of debt (Miller and Modigliani 1963, 1966). *Pecking order theory* states that firms prefer financing via internal cash flow and debt to equity because of the cost generated by asymmetric information (Ross, 1977 and Myers and Majluf, 1984). *Agency theory* is applied to multiple agents' relationships within a firm, for example, manager vs. investors, debt vs. equity holders (Jensen and Meckling, 1976; Stulz, 1990). *Market timing hypothesis* says that the choice of debt or equity depends on managers' exploitation of information asymmetries to assess which option better benefits shareholders (Baker and Wurgler, 2002). *Inertia hypothesis* argues that leverage fluctuates because managers do not rebalance debt and equity as stock prices change (Welch, 2004).

[43] Shyam-Sunders and Myers (1999) tested the static tradeoff vs. pecking order theory and found more explanatory power for the pecking order theory. Fama and French (2002) found support for both tradeoff and pecking order theory on firms' dividend and leverage policies. Frank and Goyal (2003) tested the pecking order theory using American firms 1971 – 1998 but failed to find robust support. Harvey, Lins and Roper (2004) tested the mitigation effect of debt instrument on agency and information problems. Leary and Roberts (2005) explains the slow reversion of capital structure by adjustment cost. Alti (2006) examines the market timing implication on capital structure by observing the initial public offerings on the hot market and concludes that the market timing persistency vanishes after one year. Lemmon, Roberts and Zender (2008) recently found surprisingly stable capital structure throughout years. There is also much literature on determinants of capital structure. See Titman and Wessels (1988), Rajan and Zingales (1995), and Frank and Goyal (2009).

research: earnings volatility, bankruptcy probability, asset tangibility, non-debt tax shields, advertising, R&D expenditure, profitability, growth, size, free cash flow and uniqueness.[44] Rajan and Zingales (1995) used the G-7 countries international data to study the capital structure across countries and confirmed previous findings on some of the capital structure determinants. Also, they found the explanatory power of market-to-book ratio. Frank and Goyal (2009) found among various determinants of capital structure that median industry leverage, market-to-book asset ratio, tangibility, profits, log of assets and expected inflation are the most reliable factors in determining capital structure. Parsons and Titman (2008) gives a comprehensive review on empirical research on capital structure. They review empirical literature on firms' characteristics associated with the capital structure decision-making and changes in capital structure. Besides determinants, they further extend the review to how leverage affects firms' other business decisions such as investment, pricing of products and relationship with suppliers.

Risk Management Incentives

A major motivation to manage risks is to reduce costs caused by various market imperfections as we have discussed in the above capital structure section. Specifically, these are several incentives for risk management identified in previous literature.

[44] Harris and Raviv (1991) Table IV on page 336 lists prior literatures and their findings on capital structure determinants.

Cost of financial distress

Risk management helps to reduce firms' cash flow volatility, lower the likelihood of financial distress and the cost of financial distress accordingly. Mayers and Smith (1982) argue that lower expected transaction cost of bankruptcy is one of the benefits for firms purchasing corporate insurance. Smith and Stulz (1985) find that hedging increases firms' expected value by reducing the likelihood of financial distress. Similar argument is also found in Stulz (1996) and Tufano (1996), etc. Shapiro and Titman (1986) enrich the scope of the cost of financial distress by incorporating buyer and supplier relationships, which is known as indirect cost of financial distress.

In fact, insurance companies might have greater incentive to lower the cost of financial distress because insurers, as financial institutions, are more sensitive to insolvency risk.[45] Doherty and Tinic (1981) apply M&M theory to the insurance industry. They show the relationship between insurers' ruin probability and premium income so that risk management increases insurers' shareholder value. Sommer (1996) finds a negative relationship between insurers' solvency risk and insurance prices in the property and casualty insurance industry. Cummins and Danzon (1997) develop a model of price determination in the insurance market, which predicts that the price of insurance is inversely related to insurers' default risk. Phillips, Cummins and Allen (1998) develop a model to price insurance by lines for a multiple line insurer subject to default risk. Zanjani (2002) argues that insurers' solvency risk affects their product pricing. For

[45] Cummins, Niehaus and Allen (1994) argue that NAIC risk-based capital requirements have the effect of creating nonlinear costs of financial distress. Cummins, J.D., Harrington, S. and Niehaus, G., 1994. Risk-based capital requirements for property-liability insurers: A financial analysis. In: Altman, E. and Vanderhoof, I., Editors, 1994. *The financial dynamics of the insurance industry*, Irwin Professional Publishers, Homewood, IL.

property and casualty insurers, Epermanis and Harrington (2006) find that premiums decline further in lines of business with greater risk sensitivity of demand after a rating downgrade. In the life insurance industry, Baranoff and Sager (2008) find that consumers react to rating downgrade of life insurers by reducing demand for products of downgraded insurers.

Taxes

The convexity of tax schedules for corporate income tax is another factor attracting firms to engage in risk management. Smith and Stulz (1985) claims that a firm's expected tax liability falls if hedging reduces pre-tax variability of the firm value. MacMinn (1987) shows that hedging helps firms protect income tax credit and tax loss carry-forwards. In distinction to previous literature, Graham and Rogers (2002) find no evidence that firms hedge in response to tax convexity. And they argue that firms hedge to increase debt capacity.

Underinvestment Problem or Expensive External Financing

The underinvestment problem is a typical phenomenon caused by bond and equity holders' conflict, which is also a representation of agency cost (Myers 1977). The idea is that equity holders would rather skip projects with positive net present value because debt holders have a senior claim to profits. Mayers and Smith (1987) argue that the underinvestment problem can be controlled by including a covenant in the bond contract requiring insurance coverage. Garven and MacMinn (1993) show that hedging can help to alleviate the underinvestment problem. Froot, Sharfstein and Stein (1993) approach the underinvestment problem from the perspective of costly external financing. They claim that hedging helps to ensure the corporation has sufficient internal funds to finance projects with positive net present value. Gay and Nam (1998) find that derivative use may partly be driven by the need to avoid potential underinvestment problems.

Managerial Risk Aversion

Managers cannot effectively diversify their human capital and wealth invested in companies they work for. Therefore, managers have incentives to engage in risk management. Smith and Stulz (1985) develop a model and show that if managers' compensation is a concave function of firm value, they have incentives to reduce firm cash flow variability. Petersen and Thiagarajan (2000) show that risk-averse managers have incentives to reduce risk. The extent to which they choose to hedge the risk depends on their compensation package. Rogers (2002) find that CEO risk-taking incentive is negatively related to the amount of derivative holdings that are used for hedging purpose.

Firm or Shareholder Value

Recent empirical literature focuses on whether risk management is adding firm or shareholder value and in what way. Bartram (2000) reviews theories and empirical evidence regarding the contribution of risk management to shareholder value. He finds that risk management at the firm level indeed increases firm value. In the US airline industry, Carter, Rogers and Simkins (2006) show that jet fuel hedging is positively related to firm value and they argue that hedging creates firm value through reducing the underinvestment cost. However, in the US oil and gas industry, Jin and

Jorion (2006) find hedging does not increase firms' market value. Mackay and Moeller (2007) build up a model to estimate value created by corporate risk management. Cummins, Dionne, Gagne, and Nouira (2009) study a value creation mechanism of risk management in the US property-liability insurance industry and find that risk management together with financial intermediation activities create firm value through efficiency improvement by cost reduction. Using an insurance dataset from China, Zou (2010) finds that risk management helps firms create value by securing valuable new debt financing and enhancing investment.

Risk Management by Capital and Derivative Hedging

Risk Management by Capital

In nonfinancial industries, firms manage their capital structure to balance the tradeoff between cost of financial distress and tax benefits generated from debt interest payment; to adjust external financing cost; and to control agency cost, etc. We have reviewed related theories and literature in the capital structure literature review section. In financial industries such as banking and insurance industries, capital plays an even more important role because financial institutions have to maintain solvency and meet regulatory requirements besides managing all the other similar risks or costs as nonfinancial industries. Merton and Perold (1993) identify and define the concept of risk capital for financial firms as "the smallest amount that can be invested to insure the value of the firms' net assets against a loss in value relative to the risk-free investment of those net assets". In distinction to risk-based capital and cash capital, risk capital is actually the capital designated for the firms' risk management purpose.

In the banking industry, Berger, Herring and Szego (1995) examine various fundamental aspects of capital for financial institutions such as the difference between market required capital versus regulatory required capital and how to set up regulatory capital standards. Shrieves and Dahl (1992) find that capital is positively related to risk-taking for banks. Froot and Stein (1998) develop a model to explore capital allocation and capital structure decisions for financial institutions. Diamond and Rajan (2000) use their model to show that greater capital reduces liquidity at the same time of lowering the probability of financial distress. Using Swiss banks data, Rime (2001) finds that regulatory pressure induces banks to increase capital while maintaining the risk level. Cebenoyan and Strahan (2004) argue that banks may increase their leverage while making riskier loans if they engage in other risk management methods. In their research on capital and risk controlling for efficiency for European banks, Altunbas et al (2007) find that inefficient European banks hold more capital while taking less risk than efficient banks. Mehran and Thakor (2010) build up a dynamic model to show that bank value and banks' equity capital are positively correlated.

In the insurance industry, Cummins and Lamm-Tennant (1994) provide theoretical and empirical evidence on how property-liability insurers' capital structure and lines of business affect the cost of equity capital. Staking and Babbel (1995) have several interesting findings for publicly traded property-liability insurers. They find that market value of public insurers goes up with interest rate risk when interest rate risk is at a high level. Market value goes up with leverage while leverage is at lower level and goes down with leverage when leverage is high. They infer that insurers expend scarce resources to manage the interest rate risk. Cummins and Sommer (1996) develop a theoretical model to predict the positive relationship between capital and risk. And they also prove the prediction empirically using a property-liability insurers' dataset. Myers and Read (2001) use an option pricing model to show how to allocate capital across lines of business of insurers. Froot (2007) builds a framework to analyze insurers' risk allocation, capital budgeting and capital structure. He derived the optimal hedging and capital structure strategy under imperfect product and financial markets. Shim (2010) finds that undercapitalized property-liability insurers increase capital and take more risk at the same time. Also, in the property-liability insurance industry, Harrington and Niehaus (2002) compare capital structure decision-making for stock versus mutual insurers and find that mutual insurers' capital ratios are higher on average and more sensitive to income than stock insurers because mutual insurers' financing cost is higher than stock insurers. In the life insurance industry, Baranoff and Sager (2002) find a positive relationship between life insurers' capital and asset risk. Baranoff and Sager (2003) expand the capital and risk study by incorporating insurers' organizational form and distribution channel. They get consistent findings on the positive relationship between capital and asset risk and that stock insurers take greater financial and asset risk. Baranoff and Sager (2007) employ an innovative statistical method, the structural equation modeling, to analyze life insurers' risk-taking behavior and find a positive relationship between capital and asset risk.

Risk Management by Derivative Hedging

Corporate hedging incentives and decisions have been studied for several decades. Early work focuses on theoretical rationales and later research pays more attention to empirical evidence. Stulz (1984) derives optimal hedging policies for both value-maximizing firms and risk-averse agents in the presence of uncertain future commodities prices and hedging position costs. Smith and Stulz (1985) further develop a model incorporating hedging as part of a corporate financing policy and address why firms hedge. DeMarzo and Duffie (1995) argue that financial hedging improves the informativeness of corporate earnings. Schrand and Unal (1998) provide an interesting perspective on corporate hedging. They argue that hedging is a means of allocating risk instead of reducing risk. Firms will choose to reduce risk that provides zero economic rent and increase risk that will create positive economic rent. The evidence they provide is based on the analysis of the conversion of mutual institutions to stock institutions. Stock institutions usually take more risk than mutual institutions. The author finds that institutions indeed take more overall risk after converting from mutual to stock organizational forms. After conversion, they hedge interest rate risk (reduce risk with zero economic rent) while increasing credit risk (increase risk with positive economic rent) so that the total risk increases. In empirical work, Mian (1996) examines 771 firms reporting hedging activities in 1992 and concludes that the cost of the financial distress model is not supported; there is only mixed evidence on the other corporate hedging incentives discussed in previous literature; and only the economy of scale is a confirmed factor. Gay and Nam (1998) find that firms' derivative use and growth opportunities are positively correlated, which is consistent with the argument that firms hedge to avoid the underinvestment problem. Graham and Rogers (2002) find that firms hedge to increase debt capacity instead of responding to tax convexity. Knopf, Nam and Thornton (2002) confirm that as the sensitivity of managers' stock and stock option portfolio to stock price increases, firms tend to hedge more. Gay, Lin and Smith (2010) analyze a large sample of nonfinancial firms and find that firms use derivatives to reduce their financial distress risk.

Derivative hedging is widely used in the banking industry. Shanker (1996) studies US banks from 1986 to1993 and finds that the use of interest rate derivatives helps to reduce interest rate risk. Bauer and Ryser (2004) develop a model to derive an optimal hedging strategy for banks. Pennings and Garcia (2004) focus on derivative usage of small and medium size firms and find heterogeneity regarding risk exposure, risk attitude and hedging decisions. Minton and Stulz (2005) inspect banks' credit derivatives usage and find that only a few banks in 2003 used credit derivatives and that those banks are net buyers of credit protection. This situation is caused by an illiquid credit derivative market. Bartram (2008) studies nonfinancial firms' foreign exchange rate risk management and finds managers to be aggressive in reducing foreign exchange rate risk exposure by using derivatives.

In the insurance industry, Hoyt (1989) reports survey results on usage of financial futures of life insurers and he finds the scale of economy is a major reason for using financial futures. Colquitt and Hoyt (1997) identify reasons insurers use derivatives by examining 571 life insurers' annual statements. They find support for hedging incentives such as financial distress cost, underinvestment problem, and managerial risk aversion. Cummins, Phillips and Smith (2001) conduct a comprehensive study on derivative applications of both life and property-liability insurers. They find support for previously hypothesized incentives for hedging in these two industries. Moreover, they argue that for insurers participating in derivative activities, the volume of derivative hedging is negatively related to insurers' risk appetite.

Relationship between Capital and Derivatives Hedging

Previous literature confirmed capital and derivative hedging as viable risk management tools in different industries. Some recent studies address the relationship between the two risk management tools. In fact, findings in Harrington, Mann and Niehaus (1995) hint at the substitutability of derivative hedging and capital. They study whether insurance derivatives reduce stock insurers' need for equity capital. For insurers engaging in insurance derivatives, they find that insurance futures contracts are effective in reducing insurers' correlated risk that has to be managed by *ex post* equity capital for insurers not employing insurance derivatives. While inspecting the joint determination of capital structure and investment risk, Leland (1998) also finds that hedging permits greater leverage. Purnanandam (2008) develops a model and shows empirically that leverage is positively related to hedging for moderately leveraged firms. Lin, Phillips and Smith (2008) also find a positive relationship between leverage and hedging when examining firms' hedging, financing and investment decisions simultaneously for nonfinancial industries. On the other hand, Dionne and Triki (2004) show that more hedging does not always lead to higher debt capacity and to increase debt capacity is not the purpose when firms hedge.

1.3.3 Risk-Taking Behavior Hypotheses

Finite Risk Hypothesis vs. Excessive Risk Hypothesis

Two hypotheses have been advanced to explain the capital accumulating and investing behavior of insurers. The literature entertains two opposing hypotheses about the relationship between capital and risk for insurers. One set of theories predicts that the relationship between capital and asset risk is positive. If an insurer acts to limit its overall risk, then maintaining a low level of capital (high financial risk) would lead it to pursue a conservative investment policy (low asset risk). High capital levels should also be associated with aggressive investments. In this scenario, we would expect a positive correlation between capital and asset risk. Because such theories imply that firms balance greater risk in one activity with lower risk in another, we refer to these theories collectively as the *finite risk hypothesis*. They include agency theory (starting with Jensen and Meckling, 1976), transactions cost economics (Williamson, 1985 and 1988), bankruptcy and regulatory cost, and complete markets. For example see Cummins and Sommer (1996) for the property casualty industry, Baranoff and Sager (2002 and 2003) and Shrieves and Dahl (1992) and Berger (1995) for the banking industry.

On the other hand, if an insurer does not act to limit its overall risk, then there may be situations in which the insurer seeks to increase its overall risk. Thus, maintaining a low level of capital (high financial risk) might lead an insurer to pursue an aggressive investment policy (high asset risk). In this scenario, we would expect a negative correlation between capital and asset risk. In the literature, some theories have predicted this outcome. Because they imply that greater risk in one activity may lead to greater risk in another, we refer to these theories collectively as the *excessive risk hypothesis*. The risk subsidy of guaranty funds provides one possible mechanism for the operation of this moral hazard. Others include asymmetric information, “go for broke”, signaling and adverse selection. See, for example, Cummins (1988), Berger, Herring and Szego (1995) and Downs and Sommer (1999).

Business Strategy Hypothesis

Using transaction cost economics theory as a basis, Baranoff and Sager (2003) advanced the *business-strategy hypothesis* as an explanation for the essential role of product risk in major life insurer decisions. Under the business-strategy hypothesis, an insurer’s choice of a business product is fundamental. Other financial and organizational decisions flow from that basic choice, including the trade-off between capital and asset risk that would be deemed appropriate to balance the risks of the chosen business products. The argument is that an insurer logically would make its capital structure decision mindful of the risks its products would generate and also mindful of the investment risks of its asset portfolio. Since an insurer – or any firm, in general – would not be expected to change its underlying business strategy very often, it is logical that the product risk derived from the choice of business would be a pillar undergirding other decisions.

Chapter 2

New Product Risk Measures for U.S. Life and Health Insurers

2.1 New Product Risk Measure for US Life Insurers

2.1.1 New Product and Related Product Risk

Worldwide longevity gains add to the pressure on societies to provide for aging population. Individuals increasingly fear that their financial resources will not last throughout their expected long lives. With their expertise in the risks of longevity, life insurers have long marketed private solutions for old age financial security in the form of annuities. An annuity is a contract between an individual and an insurance company that assures a future flow of income to the individual in return for accumulated premium payments. In the last two decades, as apprehension about longevity risk has grown, life insurers have innovated rapidly upon the basic design of the annuity to meet different customer needs. For example, as traditional pensions vanish, some insurer products can emulate disappearing defined benefit plans. In addition, variable annuities permit future annuitants' income flows to rise (or fall) in response to investment performance. Most recently, guarantees have been added to variable annuities to reduce their downside risks to the annuitants. Insurers limit their own downside risks in these guarantees by highly sophisticated dynamic hedging techniques.[46, 47]

[46] See: Prudential White Paper "The Importance of Financial Risk Management in Today's Variable Annuity Market" (2010) at:
http://www.prudential.com/media/managed/Financial_Risk_White_Paper_Client.pdf

Traditional variable annuities build retirement income for annuitants through investments in mutual funds that include equity and fixed income options. These annuities are *variable* because their account value and ultimate annuity, or other cash-out, depends upon the market experience of the mutual funds. In a down market, or with poor management, the annuitant could be wiped out. Since the insurer does not guarantee performance of the mutual funds in a traditional variable annuity and since the annuitant's funds are held in separate accounts and not commingled with the insurer's assets, the risk of poor performance lies solely upon annuitants. The traditional variable annuity offers no investment performance risk to the insurer. Nevertheless, the insurer earns fees from selling and servicing the products. This arrangement is not necessarily advantageous for annuitants: Chen, Yao, and Yu (2007) show that insurer-managed mutual funds perform less well than other mutual funds. However, the last ten years have seen the dramatic growth of new types of variable annuities that guarantee to protect annuitants from market declines in various ways. These guarantees transfer some of the investment risk from annuitants to the life insurers.

In the last ten years, insurers have begun to offer variable annuities with guaranteed living benefits, after the initial introduction of such products proved highly popular. Living guarantees protect annuitants in various ways during their lifetimes against equity and bond market declines. Guaranteed death benefits are another type of popular guarantee that may be attached to traditional variable annuities. Death benefit guarantees typically assure return of the initial investment upon death of the annuitant.

[47] See "Variable Annuities with Guarantees and Use of Hedging" (2011) at: http://www.genevaassociation.org/PDF/Insurance_And_Finance/GA2011-I&FSC10.pdf

Life insurers manage well the risks of death benefit guarantees through their long experience with mortality tables. Guaranteed living benefits are newer. This dissertation focuses on those variable annuities that offer guaranteed living benefits (VAGLB).[48] Generally, these guarantees are extra-cost add-on features to a basic variable annuity. Insurers must reserve against the risks of these guarantees with their own funds on their own books.

The class of living benefit guarantees includes three major sub-classes: (1) Guaranteed Minimum Income Benefits (GMIB), (2) Guaranteed Minimum Accumulation Benefits (GMAB), and (3) Guaranteed Minimum Withdrawal Benefits (GMWB). Some policies offer more than one of the three types.

1. *Guaranteed Minimum Income Benefits* protect the annuitization income of the portfolio by guaranteeing a formulaically computed minimum periodic income upon annuitization.

2. *Guaranteed Minimum Accumulation Benefits* protect the accumulated value of the annuity from market fluctuations by guaranteeing the greater of actual account value or a formulaically computed minimum.

3. *Guaranteed Minimum Withdrawal Benefits* protect against illiquidity during the deferment (accumulation) period by guaranteeing the annuitant the right to withdraw a contractual percentage of his account value, without further fee,

[48] The presentation in the 2011 Geneva Association Amsterdam Circle of Chief Economists explained the product in simple terms. Jacob Herschler (February 18, 2011) "Next Generation Lifetime Income Guarantees: Risks and Opportunities". Available at: http://www.genevaassociation.org/Research_Programme/Insurance_Economics.aspx

during and perhaps after the deferment period. GMWB is often combined with features of GMAB and GMIB to provide a product of appealing flexibility. Since its introduction in 2002, GMWB has been the most popular type of variable annuity with guarantees.

Each VAGLB contract has a portfolio account. This account belongs to the annuitant and is required to be separate from, and not commingled with, the life insurer's own accounts. Each life insurer reports the combined value of its VAGLB annuitants' portfolio accounts in its annual statement filed with the National Association of Insurance Commissioners (NAIC). This total is called the *total related account value* for the insurer. It represents the current actual market value for the portfolios of all of the insurer's VAGLB annuitants combined. The annual statement also breaks down the insurer's total related account value by the type of guaranteed benefit. The breakdown includes not just categories for the three major individual sub-classes of guaranteed living benefits, but also categories for combinations of these sub-classes. To simplify our analysis, we assign each VAGLB contract uniquely to one of the three major sub-classes. Contracts that have multiple benefit guarantees are assigned to the withdrawal type, which has the most severe risk consequences for the insurer among the three single-benefit types.[49] Clearly, a multiple-benefit contract presents more guarantee risk to an insurer than the same contract with all but one of the guarantees stripped away. However, by essentially

[49] There are 6 companies in 2006 and 7 companies in 2007 that sell some contracts with multiple guaranteed benefits. Almost all multiple guarantee contracts that we found had a withdrawal guarantee. The most common combination of guarantees is GMWB packaged with GMIB. GMAB is rarely combined with the other living benefits. In the NAIC database, we find only one insurer selling multiple guarantee contracts with GMAB and GMIB in 2007. We classify it as GMAB type because GMAB exposes insurers to more liquidity risk.

dropping all but one guarantee from multiple-benefit contracts, our assignment rule is therefore conservative in the computation of guarantee risk.

After application of our assignment rule, the total related account value for GMIB (income) products was about $220 billion at the end of 2007. GMAB (accumulation) products totaled about $60 billion; and GMWB (withdrawal) products totaled about $229 billion.

The market for variable annuities has boomed since the market recovery that began in 2002. Most of the growth has occurred in variable annuity products that offer guarantees, and especially in those that offer living benefit guarantees. There has been a surge in the total related account value. From the end of 2006 to the end of 2007, the total related account value of VAGLB annuitants grew from $383 billion to $508 billion, and the number of insurers offering VAGLB increased from 79 to 85. Around 150 life insurers offer variable annuities with some kind of guarantee. In 2008, following closely on the heels of the systemic collapse of mortgage-backed securities, came the crisis in equity and bond markets. Equity indices declined substantially. Underwriters of VAGLB confronted the need to increase reserves for contractually guaranteed returns to annuitants in the presence of negative portfolio returns. So severe was the market contraction (most equity indices had lost about 40% of their peak value by the end of 2008) that concern was raised as to the long term viability of VAGLB.

VAGLB exposes life insurers to new product risk. A typical VAGLB consists of a regular variable annuity bundled with an additional contractual guarantee of investment performance should the variable component underperform. For example, the guarantee may bind the insurer to credit the annuitant with a minimum annual return on his portfolio accumulation, even if the market value of the portfolio declines, as most equities and bonds did in 2008 and 2009.[50] Other types of living guarantees may protect the annuitization income or withdrawal benefits of the annuitant. In each case, the guarantee transfers some of the investment risk of a variable annuity from the annuitant to the insurer. The innovation of variable annuity guarantees introduces a new dimension of product risk for U.S. life insurers, which may have a negative impact on their capital structure during market downturns. In fact, the collapse in equity markets of 2008-2009 did expose the risks that insurers face in these new products. Since these products continue to grow in popularity, even after the equity crisis, concerns have been raised about the risk of insurer default on their guarantees in a future crisis and the threat that may pose to the well-being of society's retirees. Therefore, it is imperative to develop a measure that can capture and gauge the new product risk caused by VAGLB. To this end, we propose *the guarantee risk*, which will be explained next.

2.1.2 New Product Risk Measure – Guarantee Risk

Guarantee Risk Calculation

Our guarantee risk proxy encompasses a value-at-risk measure. Via simulation, we estimate the potential deficiency in the reserves that are necessary to protect against a tail event of a given probability originating from the insurer's exposure to the guarantees

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[50] The popular media have covered these products. See for example the Wall Street Journal article from 7/24/2009 "Long Derided, This Investment Now Looks Wise Thanks to Guarantees, Variable Annuities Paid Even When Stocks Didn't" by Leslie Scism.

of VAGLB.[51] To simplify the welter of contractual terms for VAGLB, we propose an archetype contract for each of the three sub-classes of guaranteed living benefits. Each VAGLB archetype has standard contractual terms. As a first-order approximation, we suppose that each VAGLB contract follows the terms of precisely one of the three archetypes. VAGLB contracts with multiple guarantees are assigned to the withdrawal type, as previously discussed. In reality, of course, actual contracts vary within guarantee categories. But we are not privy to the assortment of actual contracts, and if we were, it would be a daunting task to model each. The archetypes seem reasonably representative of their corresponding guarantee types, based upon our review of some available VAGLB prospectuses.

> *GMIB archetype contract*. There is a single initial investment. The deferment period is ten years. At the end of the deferment period, the annuitant receives a lifetime annual income equal to 5% of the greater of the actual account value or the single initial investment compounded at 5% per annum throughout the deferment period.

> *GMAB archetype contract*. There is a single initial investment. The deferment period is ten years. At the end of the deferment period, the annuitant has a choice: receive as a lump-sum the greater of actual account value or 1.2 times the single

[51] The VAGLB reserve proxy calculation (guarantee risk) is based on work of the VARWG the variable annuity reserve valuation method proposed by Life and Health Actuarial Task Force, and passed in September, 2008 by the NAIC. The variable annuity reserve valuation method is also called the Actuarial Guideline XXXXIII (AG 43), corresponding to the previous AG 34 for products with guaranteed death benefits (GMDB) and AG 39 for products with guaranteed living benefits (GMLB). AG 43 has been in effect since December 31, 2009. The scope covers all variable annuity products sold after 1981. The new reserve valuation method is highly consistent with the calculation of risk based capital C3 Phase II, effective in December 2006. In fact, both the reserve valuation calculation and the C3 calculation use the same simulation methodology.

initial investment, or annuitize and receive a lifetime annual income of 5% of the greater of the actual account value or 1.2 times the single initial investment. We suppose that 50 percent of the annuitants choose the lump-sum cash-out, and 50 percent choose to annuitize.

GMWB archetype contract. There is a single initial investment. The annuitant may withdraw 7% of the single initial investment annually, without penalty fee, for 14.2 years. However, each such withdrawal reduces the actual account value. If the actual account value reaches zero before the single initial investment has been recovered, withdrawals may nonetheless continue. After 14.2 years, all of the single initial investment will have been recovered. At that time, if the actual account value is positive, the annuitant receives the residual account balance as a lump sum payment.

For each archetype contract, we assume that all annuitants are alive at least until the end of the deferment period, that they do not surrender their policies during deferment, nor do they withdraw funds in excess of the amount contractually permitted without penalty. Usually, guaranteed living benefits expire at the end of the deferment period. Insurers' annuity risks do not expire, but their guarantee risks do. Since our focus is on the risk caused by guaranteed benefits, we terminate the calculation of our guarantee risk proxy at the end of the deferment period.

In addition to breaking down each insurer's VAGLB account values by type of guarantee, the NAIC data further break down the account values by number of years remaining in the deferment periods for contracts written prior to the year of reporting.

Our calculations take into account the number of years remaining in the deferment period. However, the remaining deferment period is not reported for GMWB (withdrawal) type products.[52] We treat GMWB products as though the year of reporting is the initial year of the contract.

In the calculation of our guarantee risk proxy, we adopt the guarantee reserves calculation method developed by the Variable Annuity Reserve Working Group (VARWG). This method is approved by NAIC and has been in effect since December 2009.[53] We construct our guarantee risk proxy by applying the VARWG method to the three archetype contracts describe above. As we noted above, this method, at its core, is similar to value-at-risk. It is based on simulation and Conditional Tail Expectation (CTE). There are two major steps in the calculation:

> Step 1 (Simulation): 10,000 portfolio return series are simulated according to historical data on major market indexes. Each of the 10,000 iterations provides hypothetical, but realistic, monthly stock and bond returns for the next 30 years.[54] For each simulated return series, we project the monthly variable annuity account values until the end of the deferment period.[55] At the same time, we calculate the

[52] By definition, withdrawals are supposed to be deferred during the deferment period. Since GMWB annuities explicitly permit withdrawals, they lack deferral.

[53] Comment on the Exposed AG VACARVM from the American Academy of Actuaries' Variable Annuity Reserve Work Group, presented to the NAIC Life and Health Task Force. The variable annuities reserves calculation method was passed by NAIC in September 2008 and was in effect after December 2009. It applies to all variable annuities sold after 1981.

[54] Equity returns and bond returns series are simulated separately. The original VARWG simulated return series are posted on the website of the American Academy of Actuaries. The historical data used for simulating the return series on the AAA website extend from 1955 to 2003.

[55] The reserve calculation method proposed by VARWG aims at the entire duration of annuity products, including the payout period. However, our focus is on the risk of guaranteed benefits during the deferment period, not on the risk caused by mortality, expenses, interest rates or other sources of annuity risk.

guaranteed contract values through the end of the deferment period according to the terms of each archetype contract. At each year end during the deferment period, the difference between the guaranteed or promised obligation in the contract and the projected annuity account value is the annual deficiency. A positive deficiency means a potential liability for the life insurer. Each iteration of the simulation thus yields a set of annual deficiencies until the end of the deferment period – one deficiency for each year of the deferment period. For each iteration, the worst of its annual deficiencies is noted. By this means, we obtain a simulated distribution of 10,000 worst-in-deferment-period deficiencies.

Step 2 (Conditional Tail Expectation): Our guarantee risk proxy, GuarRisk, is the mean of the 3,000 largest of the 10,000 worst deficiencies in the simulation.[56]

Clearly, the adequacy of our guarantee risk proxy depends critically upon having a reasonable model of future market returns for the asset classes for which the guarantees are made. Following is a brief explanation of how the market return series are generated.[57] The Life Capital Adequacy Subcommittee (LCAS) has identified 19 asset classes commonly held in variable annuities accounts. These asset classes include money market funds, U.S. intermediate term government bonds, diversified large capital U.S. equity, etc. LCAS collects historical monthly return data for the 19 asset classes, which start as early as December 1955 and end in December 2003. The 19 asset classes are

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Therefore, we terminate the projections at the end of deferment period, which is ten years for our GMIB and GMAB archetype contracts.

[56] Thus the guarantee risk is the 30 percent Conditional Tail Expectation (30 CTE).

[57] Comment on the Exposed AG VACARVM from the American Academy of Actuaries' Variable Annuity Reserve Work Group, presented to the National Association of Insurance Commissioners' Life and Health Actuarial Task Force, September 2007.

divided into bond-type assets and equity-type assets. LCAS runs simulation models for each type, incorporating intercorrelations among the 19 asset classes.[58] After estimating parameters using historical data, the models mix in normally distributed random perturbations to simulate 360 months of future returns for each asset class. The American Academy of Actuaries website provides 10,000 downloadable iterations of the simulation, where each iteration consists of the 19 simulated series for each of the next 360 months – called "Pre-Packaged Scenarios". In January 2006, LCAS released "interest rate generator" - a set of Microsoft Excel® macros to help actuaries update the simulation for bond-type assets by incorporating historical data that post-date 2003. We have utilized these macros for this paper. We also note that as of the time of this writing, the online equity simulations have not been updated to incorporate historical equity returns that post-date 2003; nor have any macros been posted for this purpose. In order to include the most recent equity returns in calculations of our guarantee risk proxy, we therefore replicated the LCAS methodology using the stochastic analysis model for equities recommended by LCAS and historical data on equity returns through the year of calculation of GuarRisk (2006 or 2007). Thus, our 30-year simulated series for both bonds and equities are based on historical data through 2006 for GuarRisk2006 and through 2007 for GuarRisk2007.

[58] Stochastic models for bonds and equities, and parameter descriptions can be found in "Recommended Approach for Setting Regulatory Risk-Based Capital Requirements for Variable Annuities and Similar Products" by Life Capital Adequacy Subcommittee (LCAS). American Academy of Actuaries, June 2005.

Archetype Examples for Guarantee Risk Calculation

Income Guarantees

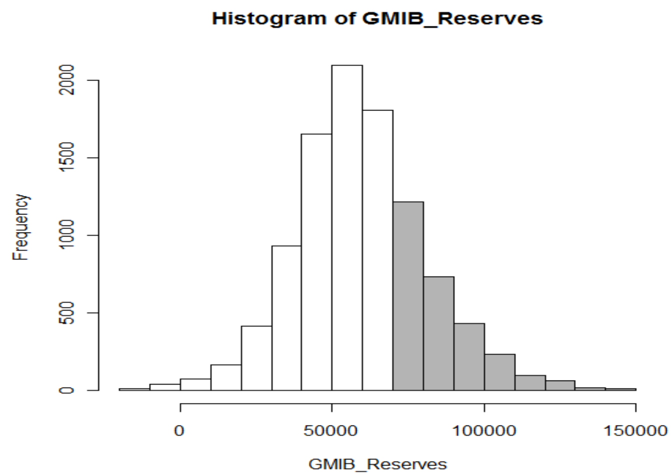
Let us suppose that Acme Life, a hypothetical insurer, has just received $100,000 in investments for variable annuity contracts with income guarantees. We suppose that all of these contracts follow the terms of the GMIB (income guarantee) archetype contract. In addition, for this illustration, we suppose that the contract funds are invested 60% in equities and 40% in bonds. In its separate accounts, Acme records a total related account value of $100,000. This is the actual account value for the annuitants. Acme sets up a corresponding shadow account, "Guaranteed Contract Value", to keep track of the guaranteed amount on which it may become obligated to pay its income guarantee. Initially, this amount is also $100,000, but will increase by 5% per year according to the terms of the GMIB archetype contract. To calculate guarantee risk for this example, the year-to-year change in actual account value is determined by simulation of market returns. 10,000 iterations are run. For each iteration, the year-to-year difference between actual annuitant account value and guaranteed amount is calculated, and the greatest annual deficiency (guaranteed amount – account value) for the (at most) 30-year duration of the iteration is recorded. To illustrate the calculations, we randomly select one simulated return series out of the 10,000.[59] At the end of the first year, the actual account value (total related account value) has increased to $108,917 because of favorable market returns (see Table 2.1, I). The Guaranteed Contract Value has grown to $105,000, per the

[59] Actually, two simulations – one for equities and one for bonds (they are correlated), since the example hypothesizes 60% investment in equities and 40% in bonds. By bad luck, we got an iteration with particularly poor returns during the deferment period, so there are many deficiencies.

contract. There have been no payouts. The GMIB archetype contract provides that the beneficiary can ultimately draw an annual income equal to 5% of the greater of the actual account value or the Guaranteed Contract Value. The actual account value is more than sufficient to cover the income guarantee in year one. There is no deficiency. In fact, there is a “sufficiency” of $3,917. These figures are shown in Table 2.1, I for year one. For year two, there is also a sufficiency. But in year three, there is a market decline and the actual account value declines to $97,687, whereas the steady growth of the income guarantee makes the Guaranteed Contract Value – the amount on which Acme may become obligated to pay income – equal to $115,763 (see Table 2.1, I). There is a deficiency of $18,076. If the income guarantee were to be triggered now, Acme is obligated to an annual payout of 5% on $18,076 more than is in the annuitants’ actual accounts. There are also deficiencies in each of the remaining years 4-10. At the end of year 10, the annuitant annuitizes the larger of the actual account value ($110,896) or the Guaranteed Contract Value ($162,889).

For the selected iteration, the worst deficiency is $53,560 and occurs in year nine. The GMIB reserve proxy calculation records the worst deficiency figure of $53,560 for this iteration. For each of the remaining 9,999 iterations, the value of the deficiency for the worst year is recorded. After 10,000 iterations of the simulation, there are 10,000 worst deficiencies, of which our illustrative $53,560 is one. Figure 2.1 displays their histogram. As the histogram shows, very few of the iterations result in sufficiency (to the left of zero); almost all result in deficiencies (to the right of zero). Moreover, the shaded region in the figure shows the worst 30% of the 10,000 iterations. The GMIB guarantee risk is defined to be the mean of these worst 30% of deficiencies (CTE30).

Figure 2.1



Accumulation and Withdrawal Guarantees

Table 2.1 cases II and III show two corresponding examples of the calculation of the guarantee risk for each of the other two categories of guaranteed living benefits. The set-up for each of these three examples is similar to the GMIB example: We again hypothesize that Acme Life receives $100,000 of funds for contracts with accumulation and withdrawal benefit guarantees, respectively. We suppose that all of these policies follow the terms of the corresponding accumulation and withdrawal benefit guarantee archetype contract. In addition, we again suppose that the funds are invested 60% in equities and 40% in bonds. In its separate accounts, Acme begins each example with a total related account value of $100,000 and a corresponding shadow "Guaranteed Contract Value". The three examples use the same market simulation as the GMIB example, but the year-to-year progression of the examples differs due to the different terms of the governing archetype contracts.

For example, in the GMAB example (Table 2.1, II), the Guaranteed Contract Value rises at a compounded rate from the initial $100,000 to the guaranteed $120,000 amount in year 10, when half the insureds take a lump-sum payout and half annuitize. The largest deficiency is $31,272, which occurs in year five.

In the withdrawal benefit example (Table 2.1, III), the beneficiary withdraws the permitted 7% x $100,000 = $7,000 annually. The withdrawal is real money, so reduces any market gain or the principal in the actual account. Moreover, the insurer no longer need guarantee the payment of the withdrawal, once paid. Thus, withdrawals reduce both the actual account value and the Guaranteed Contract Value until the initial $100,000 investment has been recovered. At that point, in year 15, there is a remainder of $7,027 in the insured's account. Per the GMWB archetype contract, the insured then receives the remainder as a lump-sum payout.

Table 2.1 Illustration of VAGLB Reserves Calculation ***

Year End	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
60% Equity 40% Bond Simulated Return Series as of 2006*															
	1.09	1.14	0.98	0.96	0.78	0.84	0.96	1.02	1.02	1.11	1.11	1.17	1.27	1.44	1.58
I. With GMIB 5% rollup, 10 years waiting period**															
Actual Account Value	$108,917	$113,630	$97,687	$96,263	$78,272	$83,784	$95,781	$102,414	$101,573	$110,896					
Guaranteed Contract Value	$105,000	$110,250	$115,763	$121,551	$127,628	$134,010	$140,710	$147,746	$155,133	$162,889					
Payout	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0					
Deficiency	($3,917)	($3,380)	$18,076	$25,287	$49,356	$50,225	$44,929	$45,332	$53,560	$51,993					
II. With GMAB 1.2 times initial premium return, 10 years of waiting period**															
Actual Account Value	$108,917	$113,630	$97,687	$96,263	$78,272	$83,784	$95,781	$102,414	$101,573	$110,896					
Guaranteed Contract Value	$101,840	$103,714	$105,622	$107,565	$109,545	$111,560	$113,613	$115,703	$117,832	$120,000					
Payout	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0					
Deficiency	($7,077)	($9,916)	$7,935	$11,302	$31,272	$27,776	$17,832	$13,289	$16,259	$9,104					
III. With GMWB 7% withdrawal each year**															
Actual Account value	$101,917	$99,327	$78,391	$70,248	$50,120	$46,649	$46,328	$42,536	$35,187	$31,417	$24,382	$18,831	$13,412	$8,228	$7,027
Guaranteed Contract Value	$93,000	$86,000	$79,000	$72,000	$65,000	$58,000	$51,000	$44,000	$37,000	$30,000	$23,000	$16,000	$9,000	$2,000	$0
Payout	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$2,000
Deficiency	($8,917)	($13,327)	$609	$1,752	$14,880	$11,351	$4,672	$1,464	$1,813	($1,417)	($1,382)	($2,831)	($4,412)	($6,228)	($7,027)

* This portfolio return series is randomly selected from 10,000 simulated return series as of year 2006. Equity returns and bond returns are simulated separately, although with correlation. The method can be found on the American Academy of Actuaries website. For this example, we assume 60% of assets allocated to equity and 40% to bond.

** Terms of various guaranteed benefit contracts (GMIB, GMAB and GMWB) can be found at the beginning of Section 2.1.2 Guarantee Risk in the article.

*** The calculation in this table reflects only Step 1 of the guarantee risk calculation described at the beginning of Section 2.1.2 Guarantee Risk. To get the final guarantee Risk, similar calculation for each type of contract will be repeated 10,000 times using 10,000 different simulated portfolio return series. See step 2 or the appendix section for details.

Guarantee Risk Proxy

To apply the guarantee risk proxy to NAIC life insurers' VAGLB data, we employ three model portfolios for the VAGLB accounts that annuitants hold with life insurers: 50% equity and 50% bond, 60% equity and 40% bond, and 80% equity and 20% bond. To be sure, actual VAGLB portfolios display a wide range of investment options. But the three model portfolios represent commonly occurring asset allocations in VAGLB accounts. For each model portfolio, we calculate the guarantee risk as of the end of 2006 and 2007 following the methodology presented above. Table 2.2 shows the guarantee risk in two years, both in absolute terms and as percentage of total related account value.

Table 2.2. Guarantee Risk of VAGLB products in 2006 and 2007, for firms with VAGLB exposure (N=74 in 2006, N=82 in 2007).

Year	Portfolio	Guarantee Risk				
		Total Guarantee Risk	Mean	50th Pctl	75th Pctl	Std Dev
2006	Stocks 50%, Bonds 50%	41,594,479,619	585,837,741	86,767,230	703,196,228	991,574,665
	Stocks 60%, Bonds 40%	47,986,981,025	675,872,972	96,724,695	813,806,286	1,133,606,104
	Stocks 80%, Bonds 20%	62,614,232,852	881,890,604	131,910,585	1,068,795,883	1,463,628,689
2007	Stocks 50%, Bonds 50%	62,787,152,580	784,839,407	112,269,569	795,781,957	1,628,882,519
	Stocks 60%, Bonds 40%	71,438,073,018	881,951,519	129,452,027	960,048,621	1,801,344,632
	Stocks 80%, Bonds 20%	91,112,557,680	1,124,846,391	167,891,917	1,278,950,249	2,222,061,575

Year	Portfolio	As Percentage of Total Related Account Value			
		Mean	50th Pctl	75th Pctl	Std Dev
2006	Stocks 50%, Bonds 50%	3.78%	2.60%	6.08%	3.71%
	Stocks 60%, Bonds 40%	4.32%	2.90%	7.12%	4.16%
	Stocks 80%, Bonds 20%	5.58%	3.81%	8.83%	5.20%
2007	Stocks 50%, Bonds 50%	4.38%	2.61%	6.26%	4.64%
	Stocks 60%, Bonds 40%	4.93%	3.09%	7.27%	5.12%
	Stocks 80%, Bonds 20%	6.30%	4.29%	9.26%	6.26%

2.2 Product Risk Measure for US Health Insurers

2.2.1 Health Insurers' Product Risk

Health insurers underwrite various health insurance policies. Their lines of business include Comprehensive, Federal Employee Health Benefits Plans (FEHPs), Medicare, Medicare Supplement or MediGap, Medicaid, Dental, Vision, other health related products (including disability, prescription drug and long term care). We described health insurers' major lines of business in chapter 1 section 1.1.3. We also discussed factors contributing to high product risk of health insurance in general. In this section, we will further analyze the factors that differentiate product risk carried by each line of business and classify major products with similar risk levels into groups.

Transaction Cost Economics (TCE) serves as the major theoretical foundation to differentiate health insurance products' risk levels. In general, the broader the coverage and the less complete the specification of coverage, the higher the product risk. The lines of business provide coverage for different types of health perils. For instance, comprehensive health insurance provides broad coverage for most types of healthcare expenses, from doctor visits and preventative services to hospital stays and surgeries. Typically, covered individuals are under 65 years old and obtain insurance through their employers. On the other hand, dental and vision insurance are limited in scope, and policies may be subject to a relatively low cap of perhaps $2,000. Health insurance policies with broader coverage and implicit definitions of medical services may expose health insurers to more uncertainties on claims and expenses and consequently embody more product risk. In the language of transaction cost economics, a health insurance contract with broad coverage is more incomplete and relational (see Williamson, 1985) than a contract of limited scope. The contracts are implicit and open to interpretation.[60] Therefore, coverage is a key factor to differentiate product risk level for health insurers' various lines of business. We classify seven major lines of business into four groups: working population group, limited coverage group, Medicare group, and welfare group.

The working population group includes comprehensive insurance and federal employee health benefit plans (FEHPs). Similar to comprehensive health insurance, FEHPs also provide comprehensive coverage, but to federal employees. Since both comprehensive health insurance and FEHPs cover people still in work force, we name this group the working population group. The comprehensive coverage of both types of health insurance contracts embodies the highest product risk. It promises coverage for a multitude of illnesses and conditions up to very large limits (and no limits per PPACA). Moreover, medical innovation introduces new treatments and procedures not anticipated by the parties to the contracts. Legislation and court rulings may expand the contract coverage. Under PPACA, there can be no limit on lifetime benefit amounts.

The limited coverage group includes dental and vision insurance. An insurer that sells primarily one type of limited benefit coverage, such as dental care or vision care, should have limited product risk. The dental and vision insurance coverage contract is usually explicit with major limits on procedures and maximum benefit amounts. For

[60] The media often report on consumers' disputes with health insurers over coverage. A much broader source for disputed claims adjustments may be found in the complaint data filed with the various states' insurance regulators.

example, coverage for dental insurance might be limited to no more than $2,000 per year regardless of the number of procedures. Therefore, we expect that substantial exposure to dental or vision coverage should confer less product risk than substantial exposure to comprehensive health coverage of the working population group.

Unlike the other lines of business, Medicare and Medicaid are public insurance administered by the Centers for Medicare and Medicaid Services (CMS). Insurers are usually contractors of CMS. Therefore, comprehensive coverage for Medicare and Medicaid are determined and monitored closely by the government. And the government also pays for much of Medicare and Medicaid costs.

The Medicare group includes Medicare and Medicare supplemental insurance. Medicare, established by the federal government in 1966, is funded by the Federal government by a mandatory tax on worker salaries. Payment of the tax during working years qualifies workers for comprehensive Medicare coverage when they reach 65 years of age.[61] Part A of Medicare covers hospitalization; Part B covers doctor visits. The Balance Budget Act of 1997 established a new part for the Medicare program – Medicare Advantage (MA) or Medicare Part C, which allows private health insurers to participate in Medicare by offering coverage that wraps Parts A and B with additional coverage like prescription drugs. The primary intent of the MA program is to reduce Medicare costs by funneling Medicare beneficiaries into managed care programs in which private health insurers have considerable experience and expertise. The incentive for Medicare beneficiaries is the availability of additional coverage at little extra cost. A disincentive is

[61] Medicare also provides coverage for people under 65 with certain disabilities and people of all ages with end-stage renal disease (permanent kidney failure requiring dialysis or a kidney transplant), www.cms.gov.

the number of restrictions in managed care, such as choice of physician. Medicare Part C or MA bundles Medicare Part A, Part B and additional coverage. Medicare Part A and Part B coverage is monitored and sponsored by the federal government (not-at-risk portion). And the additional coverage exposes health insurers to financial risk (at-risk portion). However, when reporting to NAIC, health insurers do not unbundle their data so that the at-risk portion of Part C is separated from the not-at-risk portion.

Underwriting MA exposes health insurers to comprehensive product risk. However, in practice, the amount of MA risk may be limited for various reasons. First, MA coverage is defined and administered by CMS, which processes the most comprehensive medical services data and research on the national level. CMS uses an extensive coding system to monitor all medical services provided to beneficiaries. The Current Procedural Terminology (CPT) code was adopted by the CMS Healthcare Common Procedure Coding System (HCPCS) in 1983 and is maintained by the American Medical Association (AMA), which explicitly defines each medical service provided.[62] Comprehensive historical data and research help to improve actuarial results and reduces MA product risk. Second, contracting with CMS effectively reduces health insurers' risk exposure. Health insurers follow actuarial instructions to submit bids for MA business every year.[63] CMS has a benchmark for each geographic area to determine the payment for medical services. If an insurer's bid is below the benchmark, CMS will pay the bid amount adjusted for individual risk factors plus a rebate with the amount determined by

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[62] Center for Medicare and Medicaid Services (CMS), http://www.cms.gov/MedHCPCSGenInfo/
CPT Process – How a Code Becomes a Code, www.ama-assn.org

[63] http://www.cms.gov/MedicareAdvtgSpecRateStats/09_Bid_Forms_and_Instructions.asp#TopOfPage is the bid pricing tools and instruction on CMS website that is updated annually.

law. If the bid is equal to or above the benchmark, CMS will pay insurers the amount of the benchmark adjusted for individual risk factors plus a subsidy.[64] Under the current payment scheme, CMS will cover both efficient and less efficient health insurers' cost. Therefore, the product risk carried by MA is reduced to the minimal level for health insurers.

Medicare supplement insurance is another type of insurance related to Medicare, but distinct from Parts A, B and C. Medicare supplement is secondary insurance; Medicare is primary. Medicare beneficiaries may purchase Medicare supplement from private health insurers to cover certain out-of-pocket expenses that exceed Medicare payments, such as copayments and deductibles. Medicare supplemental insurance is contingent upon basic Medicare coverage. The market size of Medicare supplemental insurance is limited as well (see Table 1.3 and 1.4). Therefore, we combine Medicare and Medicare supplemental insurance and call it the Medicare group.

The welfare group refers to Medicaid. Medicaid is jointly funded by the states and the Federal government. Beneficiaries are usually low-income mothers and children, elderly and disabled individuals. Even though a government funded program, Medicaid exposes health insurers to product risk. The contributing factors are: variation of coverage contingent upon the financial situation of each state and beneficiaries' health status. Unlike Medicare, Medicaid is administered at the state level. The scope of its

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[64] Medicare Managed Care Manual, Chapter 1, http://www.cms.gov/Manuals/IOM/itemdetail.asp?filterType=none&filterByDID=-99&sortByDID=1&sortOrder=ascending&itemID=CMS019326

comprehensive coverage varies from state to state.[65] State-administered Medicaid programs have been putting effort into controlling and cutting cost by managed care. In recent years, Medicare managed care enrollment went from 55.76% in 2000 to 71.73% in 2009.[66] On the other hand, PPACA requires state Medicaid programs to incorporate National Correct Coding Initiative (NCCI) in their claim processing system by October 1st, 2010.[67] These factors may help to unify state-administered Medicaid programs in the future. However, health insurers underwriting Medicaid during the period of our dataset were still exposed to more uncertainties. In addition, the Henry J. Kaiser Family Foundation report shows that Medicaid enrollees are poorer and sicker than the low-income privately insured population.[68] Poorer health status brings more uncertainties to the coverage resulting in higher product risk level.

As a brief summary of the above discussion, applying transaction cost economics (TCE), we classify health insurers' major lines of business into four groups based on product risk level: working population group (comprehensive and FEHPs insurance), limited coverage group (dental and vision insurance), Medicare group (Medicare and Medicare Supplement insurance), and Welfare group (Medicaid).

[65] 'Understanding Healthcare Financial Management', Louis Gapenski, Health Administration Press, Chicago Louis Gapenski, Page 68
[66] 'National Summary of Medicaid Managed Care Programs and Enrollment As of June 30, 2009', Center for Medicare and Medicaid Services (CMS)
[67] Center for Medicare and Medicaid Services, http://www.cms.gov/MedicaidNCCICoding/
[68] Who Needs Medicaid?, The Kaiser Commission on Medicaid and Uninsured, April 2006

2.2.2 Product Risk Measures for U.S. Health Insurers

To assess health insurers' product risk, we develop exposure-based measures for the working population group, limited coverage group, Medicare group, and welfare group. Specifically, we use the premium income of an insurer from each of the four types, divided by total assets of the insurer. We propose the ratio as health insurers' product risk proxy. Therefore, we have four corresponding product risk proxies for each group: working population product risk, limited coverage product risk, Medicare product risk, and welfare product risk. For insurers who do not underwrite a specific line of business, the NAIC dataset records zero premium income. Accordingly, the product risk of a specific group will be zero if an insurer does not underwrite any lines of business in that group. Table 2.3 summarizes the four product risk proxies. Table 2.4 shows summary statistics for the product risk proxies of U.S. health insurers for 2002, 2004, 2006, and 2008.

Table 2.3 Health Insurers' Product Risk Proxies

Variables	**Description**
Working Population Product Risk	(Comprehensive Premium Income + FEHPs Premium Income) / Total Assets
Limited Coverage Product Risk	(Dental Premium Income + Vision Premium Income) / Total Assets
Medicare Product Risk	(Medicare Premium Income + Medicare Supplement Premium Income) / Total Assets
Welfare Product Risk	Medicaid Premium Income / Total Assets

Table 2.4. Summary Statistics for NAIC Health Insurers 2002, 2004, 2006 and 2008

	2002				2004			
Variable	**N**	**Mean**	**Std Dev**	**Median**	**N**	**Mean**	**Std Dev**	**Median**
Working population product risk*	458	2.312	1.655	2.178	447	2.183	1.636	2.031
Limited coverage product risk*	250	2.212	4.022	1.294	246	1.907	2.374	1.17
Medicare product risk*	216	0.885	1.238	0.414	223	0.993	1.589	0.364
Welfare product risk*	177	2.226	3.459	1.265	168	2.096	2.352	1.401
	2006				**2008**			
	N	**Mean**	**Std Dev**	**Median**	**N**	**Mean**	**Std Dev**	**Median**
Working population product risk*	451	2.076	1.508	1.867	452	1.909	1.357	1.719
Limited coverage product risk*	268	1.808	2.357	0.99	269	1.75	2.356	0.974
Medicare product risk*	304	1.093	1.486	0.543	380	1.299	1.705	0.637
Welfare product risk*	178	2.052	2.023	1.682	183	1.983	1.766	1.588

* Product risk is as defined in Table 2. Summary statistics for product risk in this table are in raw form (not logarithms) and include only health insurers with positive premium income in a specific group. Product risk may exceed 1 because the total premium income in each group (the numerator) may exceed total assets (the denominator). Health insurers experience large inflows and outflows of cash in relation to their assets.

Chapter 3

Product Risk Management in the Context of Other Enterprise Risks

3.1 Risk Management by Capital under New VAGLB Product Risk in U.S. Life Insurance Industry

3.1.1 Hypothesis to Be Tested

In examining the risk management of U.S. life insurers, we would like to test whether life insurers operate under risk limiting mode (*finite risk hypothesis*) or risk seeking mode (*excessive risk hypothesis*).

The *finite risk hypothesis* (see Baranoff and Sager, 2002 and 2003 and Baranoff, Papadopoulos and Sager, 2007) posits a positive relationship between capital and the various enterprise risks: the greater the risk, the greater the capital, *ceteris paribus*. Under this hypothesis, insurers tend to balance the assumption of more of one type of risk with the reduction of another type of risk. Thus, if the addition of living guarantees to variable annuities contracts increases insurer product risk, we may expect an insurer to raise capital, *ceteris paribus*. An opposing hypothesis, the *excessive risk hypothesis* (Baranoff and Sager, 2002 and 2003 and Baranoff, Papadopoulos and Sager, 2007) maintains that under certain conditions, the assumption of additional risk in one area can trigger still further risk taking in another, such as the reduction of capital. The events in the financial markets of 2008 provide large-scale tests for the roles of these hypotheses in life insurer behavior.

3.1.2 Data and Summary Statistics

Our selection of variables is motivated by conventional capital structure modeling, together with the special concerns of the current study. We use data from annual filings of life insurers with the NAIC for 2006 and 2007. The total account value and reserve for variable annuities with guarantees are taken from page 22.1 in the NAIC annual filing for those years.

Three key variables are capital, asset risk, and guarantee risk. We study how life insurers balanced their capital against asset risk and guarantee risk (reflecting the risk of VAGLB) in 2006 and 2007. The three variables are scaled to help neutralize the effects of insurer size. For capital, we define CAP = book value of insurer capital / total insurer assets. For asset risk, we scale OAR (asset risk) by dividing by insurer total invested assets. For VAGLB guarantee risk, we first scale the VAGLB guarantee risk proxy by dividing by total related account value. Then we apply neglog transformation to include all insurers with VAGB business.[69] CAP and OAR are also used in log form in order to reduce skewness.

"Business strategy" variables are used in the analysis. The business strategy refers to the mix of product specialties in which an insurer does most of its business. Baranoff and Sager (2003) find that the greater the uncertainty regarding the outcome of an

[69] Guarantee risks can be negative, zero or positive. Neglog transformation is a technique to adjust for the skewness for variables with negative, zero or positive values. Specifically, for insurers with negative or zero guarantee risk, neglog transformation is NegLog(GuarRisk) = log(1 - GuarRisk); for insurer with positive guarantee risk, neglog transformation is NegLog(GuarRisk) = log(1 + GuarRisk). See Whittaker, Whitehead, and Sommers (2005).

insurance product, the greater the impetus for financing via capital. They argue that the major categories of life insurance products (annuities, life insurance, health and accident insurance, reinsurance) carry distinctive risk characteristics that differentially inform insurer behavior. We use the proportion of writings in each line (pAnnuity, pLife, pHealth) to capture business strategy effects.[70] Each proportion assesses the extent of insurer involvement with the corresponding product. Because of our emphasis in this paper on guarantee risks, we extend Baranoff and Sager's business strategy variables to include an additional business strategy variable, pVAGB, that similarly measures the extent of the insurer's involvement with VAGB products. pVAGB is the total account value of variable annuities with guaranteed benefits, divided by life insurers' total assets. Note that the numerator of pVAGB tallies the related account value for all types of guarantees, both living benefits and death benefits, although the focus of our risk analysis for this paper is on living benefits. By broadening the business strategy variable to include death benefits as well as living benefits, this strategy variable therefore looks to the offering of any type of guarantee as the essential strategic and behavioral differentiator among insurers, rather than the type of the guarantee. However, in the risk analysis of this paper, we look to living benefit guarantees as more worrisome than death benefit guarantees, both for the insurer and for society (in the form of possible systemic risk). Note also that the pVAGB predictor is used in our analysis as a control for business strategy rather than as a direct measure of guarantee risk. Therefore, pVAGB should not be confused with GuarRisk, our proxy for the risk of living benefit guarantees. To be sure,

[70] We omit reinsurance to avoid a multicollinearity.

one could argue that pVAGB may represent an exposure risk for benefit guarantees. But to the extent that it actually does so, its presence as a predictor in our models may attenuate the effect of GuarRisk, therefore conservatively reducing the significance that we find for GuarRisk.

Three of our control variables represent measures of firm size (total assets, total premiums, and total liabilities). These are strongly correlated with each other. To reduce the possibility of multicollinearity, these three variables are combined by taking the logarithm of their geometric mean (logSize). A principal components analysis suggests that the first principal component of the three (log) variables explains well over 90% of their variation and weights each variable about equally, whether the components are extracted in standardized or unstandardized mode. Applying the logarithm also reduces the skewness of the distribution. The life risk-based capital ratio (RBCratio) is included as an indication of regulatory forbearance. As a performance and/or earnings indicator, return on capital (RetOnCap) is included (e.g., Berger, 1995; and Berger and Patti, 2006 – both studies for banks). Insurers that are members of an affiliated group of firms may have superior access to investment opportunities and may have different mechanisms for monitoring and/or controlling managerial performance and structuring their capital and asset risk. To capture this possibility, we include a 0-1 indicator for whether the insurer is a member of a group (NGROUP). Stock insurers and mutual insurers are faced with different financing costs when raising capital (Laux and Muermann, 2010). Therefore, stock insurers and mutual insurers may manage their capital differently. So we include a 0-1 indicator for whether an insurer is a stock firm (NTYPE). Underwriting VAGB products exposes life insurers to more market risk. Insurers may hedge that risk by use of derivatives. An insurer's posture toward capital accumulation is affected by its willingness to manage risk by hedging. Therefore we include a 0-1 indicator for whether an insurer is active in derivative use (IndDeriv).

Table 3.1 lists definitions of variables used in our analysis. Table 3.2 provides summary statistics for those variables in year 2006 and 2007 separately. There are 145 insurers underwriting VAGB products in each year. In 2006, 66 insurers provided guaranteed death benefit only. In 2007 such insurers are 60 in number. Therefore, 79 life insurers underwrote VAGLB in 2006 and 85 in 2007. Ultimately, we could use 78 insurers in 2006 and 84 in 2007. Two insurer-years were dropped on account of outlier and wrong data record.

Table 3.1 Definitions of Additional Variables

Variable Name	**Definition**
CAP	Capital/Assets
Atotal	Total assets
Wtotal	Total writings
LiabTot	Total liabilities
logSize	Log(Atotal*Wtotal*LiabTot)/3
OAR	Opportunity asset risk / Total invested assets
pHealth	Health writings / Total writings
pAnnuity	Annuity writings / Total writings
pLife	Life writings / Total writings
pVAGB	Total account value for VAGB / Total assets
RBCratio	100*Market capital / (2*Authorized capital)
RetOnCap	Income / Book capital
Ntype	Organizational type (1=Stock)
Ngroup	Indicator for member of affiliated group (1=Yes)
IndDeriv	Indicator of derivative activity (1=Yes)

Table 3.2 Summary Statistics for Key Capital Structure Variables for Life Insurers Underwriting VAGB

Variables 2006	N	Sum	Mean	Std Dev	1st Quartile	Median	3rd Quartile
CAP	145		0.0921	0.1120	0.0433	0.0640	0.0981
Atotal	145	3,830,685,200,000	26,418,518,376	44,764,847,784	3,046,829,441	9,123,635,604	23,761,828,797
Wtotal	145	476,032,106,152	3,282,980,042	5,379,762,852	320,369,479	1,057,279,433	3,763,512,029
LiabTot	145	3,641,875,300,000	25,116,381,478	42,994,424,529	2,721,114,704	8,197,606,470	22,166,484,495
OAR	145		0.0020	0.0003	0.0018	0.0020	0.0022
pHealth	145		0.0786	0.1698	0.0000	0.0070	0.0655
pAnnuity	145		0.5333	0.3566	0.1977	0.5425	0.8597
pLife	145		0.3072	0.3200	0.0344	0.1988	0.4880
pVAGB	145		0.3738	0.3715	0.0382	0.2694	0.6091
RBCratio	144		918.9842	2227.4400	366.1404	453.1382	645.2311
RetOnCap	144		0.0825	0.2211	0.0451	0.0910	0.1592
Ntype	145	133	0.9172	0.2765	1	1	1
Ngroup	145	139	0.9586	0.1999	1	1	1
IndDeriv	145	86	0.5931	0.4930	0	1	1
Variables 2007	**N**	**Sum**	**Mean**	**Std Dev**	**1st Quartile**	**Median**	**3rd Quartile**
CAP	145		0.0927	0.1136	0.0405	0.0644	0.1031
Atotal	145	4,179,415,600,000	28,823,555,524	48,358,960,459	3,211,690,427	9,917,632,927	29,148,525,843
Wtotal	145	519,665,567,571	3,583,900,466	5,842,884,558	377,420,109	1,087,582,798	3,911,472,033
LiabTot	145	3,971,196,000,000	27,387,558,695	46,265,581,890	2,907,608,884	8,956,359,021	27,414,019,709
OAR	145		0.0022	0.0009	0.0016	0.0019	0.0023
pHealth	145		0.0853	0.1768	0.0000	0.0089	0.0658
pAnnuity	145		0.5214	0.3626	0.1363	0.5284	0.8732
pLife	145		0.2972	0.2953	0.0534	0.1946	0.4621
pVAGB	145		0.3738	0.4118	0.0301	0.2104	0.5695
RBCratio	144		849.5911	1704.8900	359.8129	458.4470	678.3760
RetOnCap	144		0.0425	0.2690	0.0261	0.0764	0.1231
Ntype	145	132	0.9103	0.2867	1	1	1
Ngroup	145	140	0.9655	0.1831	1	1	1
IndDeriv	145	89	0.6138	0.4886	0	1	1

3.1.3 Empirical Methodology

To address our major questions, we develop standard capital structure models that show the relationship between the capital ratio, on the one hand, and a number of recognized risk factors and control variables, on the other hand, including OAR (asset risk) and GuarRisk (VAGLB guarantee risk). The finite risk hypothesis predicts that an increase in one type of insurer risk will be compensated by a reduction in another type of risk. For example, an increase in asset risk (such as OAR) or an increase in product risk may be balanced by an increase in capital [reduced leverage and financial risk]. In fact, Beatty, Gron, and Jorgenson (2005) found that a sample of nonfinancial firms that had dropped product liability insurance actually reduced overall firm risk through compensating risk management strategies. Among articles about the insurance industry, Cummins and Sommer (1996) for the property/casualty insurers and Baranoff and Sager (2002 and 2003) for life/health insurers have also found empirical support for finite risk. In our capital regression models, we therefore expect to find positive coefficients for OAR and GuarRisk if this hypothesis prevails. The excessive risk hypothesis (Baranoff and Sager, 2002 and 2003) predicts that an increase in one type of risk can trigger still further risk in another, such as the reduction of capital. Hypothesized circumstances that could promote excessive risk taking include a “go-for-broke” attitude in the presence of a moral hazard, such as guarantee funds. If this hypothesis holds, we may expect to find negative coefficients for OAR and GuarRisk in a regression model for capital.

The methodology is conventional regression, with a tweak to adjust for autocorrelation. Since we have a panel data set with the same insurers in two different years, within-insurer autocorrelation should be taken into account. We use Generalized Estimating Equations (GEEs) methodology for this purpose (Liang and Zeger, 1986). Statistically insignificant control variables have been dropped from the model.

3.1.4 Empirical Results and Discussion

We investigate first the posture of those insurers that underwrote VAGLB towards the guarantee risk of VAGLB. Were these insurers in a finite risk or an excessive risk mode? Table 3.3 shows the fitted capital structure model in three panels, corresponding to the three VAGLB model portfolios. The data for the three panels are the same, except only for the calculation of the VAGLB risk variable, GuarRisk, which varies according to the proportion of stocks and bonds in the model portfolio.

Table 3.3 Benchmark Capital Structure Model - Dependent Variable is log (capital/total assets). Three Scenarios for VAGLB Risk using 288 Firm-years 2006 - 2007

Panel A: 50% Equity 50% Bond

Parameters	Estimates	Std Err	Z-Value	P-Value
Intercept	1.8886	0.2666	7.08	<.0001
logOAR	0.0756	0.0027	27.90	<.0001
logGuarRisk50/50	-0.6975	0.0543	-12.84	<.0001
Size	-0.2790	0.0065	-43.12	<.0001
pHealth	-0.1043	0.0336	-3.11	0.0019
pLife	0.0601	0.0094	6.40	<.0001
pVAGB	0.0506	0.0049	10.37	<.0001
logRBCratio	0.4193	0.0054	77.25	<.0001
RetOnCap	0.0410	0.0036	11.54	<.0001
Ntype	-0.6329	0.2285	-2.77	0.0056

IndDeriv	-0.1137	0.0048	-23.57	<.0001
Scale	0.8142	.	.	.
R^2	0.3318			

Panel B: 60% Equity 40% Bond

Parameters	Estimates	Std Err	Z-Value	P-Value
Intercept	1.9584	0.2672	7.33	<.0001
logOAR	0.0759	0.0027	27.92	<.0001
logGuarRisk60/40	-0.5755	0.0493	-11.68	<.0001
Size	-0.2819	0.0065	-43.56	<.0001
pHealth	-0.1092	0.0337	-3.25	0.0012
pLife	0.0597	0.0094	6.32	<.0001
pVAGB	0.0492	0.0049	10.04	<.0001
logRBCratio	0.4189	0.0054	76.90	<.0001
RetOnCap	0.0419	0.0036	11.74	<.0001
Ntype	-0.6351	0.2293	-2.77	0.0056
IndDeriv	-0.1136	0.0048	-23.45	<.0001
Scale	0.8170	.	.	.
R^2	0.3313			

Panel C: 80% Equity 20% Bond

Parameters	Estimates	Std Err	Z-Value	P-Value
Intercept	2.0718	0.2682	7.72	<.0001
logOAR	0.0765	0.0027	27.98	<.0001
logGuarRisk80/20	-0.3925	0.0406	-9.68	<.0001
Size	-0.2866	0.0065	-44.30	<.0001
pHealth	-0.1168	0.0338	-3.45	0.0006
pLife	0.0581	0.0095	6.10	<.0001
pVAGB	0.0475	0.0049	9.61	<.0001
logRBCratio	0.4184	0.0055	76.33	<.0001
RetOnCap	0.0431	0.0036	12.04	<.0001
Ntype	-0.6389	0.2307	-2.77	0.0056
IndDeriv	-0.1138	0.0049	-23.32	<.0001
Scale	0.8220	.	.	.
R^2	0.3304			

We find support for the finite risk hypothesis in life insurers' asset risk-taking and risk-taking in conventional products such as life insurance and health insurance. The positive coefficient of logOAR suggests that the industry posture was to expand capital if asset risks increase. The coefficient represents an elasticity since both dependent and independent variables are in log scale. So, a one percent increase in asset risk would be expected to produce about a 0.08 percent increase in the capital ratio for all model portfolios, *ceteris paribus*.

Interestingly, we also found support for the excessive risk hypothesis in life insurers' risk-taking on VAGLB products. The negative coefficients of logGuarRisk50/50, logGuarRisk60/40, logGuarRisk80/20 indicate that insurers with more guarantee risk for living benefits have lower capital ratios than insurers with less guarantee risk, *ceteris paribus*. Even though both the dependent variable logCAP and the VAGLB guarantee risk are in logarithm, the coefficients of the guarantee risk are no longer elasticities because of neglog transformation on the guarantee risk as explained in the footnote in section 3.1.2. In fact, the actual elasticity is smaller than the coefficients in the results.[71] A possible explanation for negative coefficients of VAGLB guarantee risk is suggested by widespread use of derivatives among our panel of insurers that write VAGLB (56 of 79 insurers underwriting VAGLB in 2006 and 63 of 85 in 2007). In the

[71] The coefficients of predictors in a regression are elasticities when both the dependent and independent variables are in logarithmic scale. For example, when logY = βlogX + ε, the coefficient $\beta = \partial \log Y / \partial \log X = (\partial Y / Y)/(\partial X / X)$, which is just the elasticity. By neglog transformation, the regression equation changes to logY = βlog(X+1) + ε. $\beta = \partial \log Y / \partial \log(1+X) = (\partial Y / Y)/[\partial(1+X)/(1+X)] = (\partial Y / Y)/[\partial X /(1+X)]$, which is greater than $(\partial Y / Y)/(\partial X / X)$, the elasticity.

model of Table 3.3, the negative coefficient for derivative use suggests that insurers that use derivatives have lower capital ratios than insurers that do not use derivatives, *ceteris paribus*. Insurers may believe that the use of derivatives to hedge the additional asset-related risks of guarantees provides a sufficient offset to these new risks and therefore that further capital need not be accumulated for that purpose.[72]

Results for the four business strategy variables are generally as expected. Only the annuities variable (pAnnuity) is not significant and is therefore omitted and uncontrolled in the model of Table 3.3. Positive coefficients on pHealth and pLife indicate that capital is accumulated as exposures to the risks of writing health and life insurance increase. The larger coefficient of pHealth supports the notion, argued by Baranoff and Sager (e.g., 2003), that health insurance is relatively riskier to the insurer than life insurance – and that both are relatively riskier than annuities, which have no impact on capital for this panel of insurers in this model. A possible surprise is the negative coefficient of the guarantee exposure variable pVAGB. However, the discussion of the risk-mitigating effect of derivative use in the preceding paragraph may provide a corresponding explanation.

[72] "It has been noted that regulatory reserve and capital requirements drive life insurers to employ effective hedging techniques to mitigate the risks in order to optimally reduce capital and reserve requirements." (Liedtke and Schanz, 2010).

3.2 Risk Management by Capital in U.S. Health Insurance Industry

3.2.1 Hypotheses to Be Tested

In examining the risk management of U.S. health insurers, we would like to test two major hypotheses as we already discussed in chapter 1: *finite* vs. *excessive risk hypothesis* and the *business-strategy hypothesis*.

If the *finite risk hypothesis* (or risk-limiting or risk-averse hypothesis) describes the behavior of health insurers, then we expect to find that health insurers that assume high asset risk through their choice of investments would accumulate large amounts of capital as a counterbalance and vice versa. On the other hand, if the *excessive risk hypothesis* (or risk-seeking hypothesis) prevails, then we expect to find high asset risk associated with low capital accumulations and vice versa. In our models, we examine evidence for these two hypotheses in the interrelationship between capital and asset risk as simultaneously interacting endogenously determined variables.

As we discussed in chapter 1, the *business-strategy hypothesis* argues that an insurer's choice of business product is fundamental. Other financial and organizational decisions flow from that basic choice, including the trade-off between capital and asset risk that would be deemed appropriate to balance the risks of the chosen business products. The argument implies that there is an effect that runs from product risk to capital and asset risk. Therefore, the argument could support the treatment of product risk as econometrically pre-determined. But the argument does not preclude a bi-directional effect. If an effect also runs from capital and/or asset risk to product risk, then product risk should be treated as endogenous, along with capital and asset risk.

Baranoff and Sager (2002) treated product risk as endogenous in their study of the life insurance industry. For life insurers, it is plausible that capital and/or asset risk could affect product risk. When a firm selects life insurance as a business strategy, the firm must not only choose the life industry, but also it must choose a mix of life products. The life industry offers a diversified array of products of varying risks, from relatively low risk annuities to high risk health insurance. If a life insurer experiences an increase in market risk of its asset portfolio, for example, the insurer potentially could balance that increase in asset risk by adjusting its mix of life products, (for example, to put more emphasis on annuities and less on health) and still remain with the life industry.

On the other hand, the U.S. health insurance industry differs sufficiently from the life insurance industry that one may question a bi-directional role for product risk among health insurers. The choice of health insurance as the business product should still affect capital and asset risk choices, per the *business-strategy hypothesis*. However, the reverse direction is more problematic. By choosing to be a health insurer, a firm has already chosen a high degree of product risk. Moreover, the health industry is more homogeneous in its products than the life industry is. There is one dominant health line – comprehensive – with many attributes of high risk and with which most health insurers are involved at substantial exposure levels. As long as a firm remains a health insurer, it may have less scope to vary product risk in response to changes in capital or asset risk.

We are therefore open to the possibility that product risk for the health insurance industry could be either pre-determined or endogenous. To resolve the issue, we appeal to the Durbin-Wu-Hausman test of endogeneity (Wooldridge, 2002), which we apply to capital, asset risk, and product risk in our model. We find that non-endogeneity is rejected for capital and asset risk, but cannot be rejected for product risk.

We therefore treat product risk as econometrically *pre-determined*. [73] Logically, this implies that product risk could influence capital and asset risk choices, but that capital and asset risk choices would generate minimal feedback to product choices. We also use other risk measures and control variables to help isolate the impact of the product risks on the capital and asset risk decisions. These additional variables include loss ratios and utilizations. To test the business strategy hypothesis in this setup, we look to the statistical significance of our product risk proxies in our model. We find that product risk has significant effects upon capital and asset risk in our two structural equations.

3.2.2 Data and Summary Statistics

The dataset was extracted from the annual statements filed by U.S. insurers with the National Association of Insurance Commissioners (NAIC) for 2001 – 2008. Our sample is a panel that numbers 735 health insurers in 2001 and increases to 878 in 2008.

[73] A predetermined variable may be distinguished from an exogenous variable conceptually by asking whether the variable values are really set externally to the firm (exogenous), or are merely treated as given (predetermined). For estimation purposes, both cases are treated the same.

Altogether, there are 6,431 firm-years of data.[74] The NAIC data provide detailed reporting on different lines of health business, which include comprehensive, Federal programs (equivalent to comprehensive), dental, vision, Medicare supplemental, Medicare and Medicaid.[75] Next, we will discuss how we define all the variables we use in our analysis except product risk proxy and asset risk proxy since we have covered them in previous chapters.

Variable Descriptions

Capital ratio

For capital, we use the ratio of total book capital to total assets. A high capital ratio is associated with low risk; a low capital ratio is associated with high risk. For nonfinancial firms, the debt-to-equity ratio is often used to assess this source of risk. However, insurers typically have little conventional debt, since most liabilities are in the form of actuarially calculated reserves for paying future claims.

Control Variables

Table 3.4 lists the definitions of all variables used in our model. The predetermined/exogenous controls include firm size, which has been implicated in many studies as an important factor for capital and risk. In this study, many of the key variables have already been adjusted for size by conversion to ratios (CAP = capital-to-asset ratio,

[74] After excluding 56 firm-years for which the capital ratio was anomalously outside the range 0 to 1.
[75] Medicare and Medicaid processed for Centers for Medicare and Medicaid Services.

RBCratio, RetOnCap = net income / capital, Product Risk and Asset Risk are as described above). But we include size explicitly to mop up remaining unadjusted effects. Three obvious size proxies are total assets, total liabilities, and total premiums collected. These three are rather highly correlated with each other, however, and their inclusion as a group in a regression model may induce collinearity issues. Therefore, we decided to combine them by taking the logarithm of their geometric mean and calling the result *Size*.[76]

Since the insurance industry is highly regulated, we use the risk-based capital ratio (*RBCratio* = 100 * Total market capital / (2 * total authorized risk capital)) as an indicator of regulatory forbearance. *Return on capital* (total income / total market capital) is also included as an indicator of earnings and performance (Berger, 1995; and Berger and Patti, 2006). Agency theory predicts that the governance type of insurance companies (stock or mutual) affects their risk taking behavior. So an indicator variable (*Stock insurer* = 1 if stock company, = 0 if not) is used to represent the governance type. If an insurer belongs to an affiliated group of companies, access to the resources of sister firms might affect the insurer's risk taking behavior. Another indicator variable (*In group* = 1 if a member of an affiliated group, = 0 if not) is included for this reason. *Use derivatives* (= 1 if there is derivative activity, = 0 if not) is taken as an indicator for sophistication of health insurers. The number of states in which a health insurer is licensed to conduct

[76] Supporting this approach is the fact that a principal components analysis showed that the first principal component explains 95% of the variation of the group. Furthermore, the factor loadings of the three are about equal, which supports the equal weighting implied by the geometric mean.

business (*States of licensure*) may also affect its risk management behavior, because health insurance product risk is related to geographic and demographic factors.

In addition to the above generic exogenous variables, we also include two sets of predictor variables that are specific to the health insurance industry, loss ratio and utilization. The *loss ratio* is defined as the underwriting deduct (the sum of total hospital and medical expenses, claims adjustment expenses, administrative expenses, and the increase in reserves) divided by total premium income from health insurance. If an insurer does not underwrite a specific group of lines of business, we record zero loss ratio for that group. The loss ratio represents the fraction of health insurance income attributable to claims and other charges that originate from health insurance underwriting. It is an important indicator of health insurers' underwriting performance or profitability. A high loss ratio means low profitability. Besides loss ratios for each group individually, we also examine the total health loss ratio as an overall profitability indicator for each insurer.

We evaluate *Utilization* of medical services by three factors: number of provider encounters, number of hospital patient days, and number of inpatient admissions. First, we divide the number of medical services of each group by corresponding premiums of that group. In this way, we obtain the number of provider encounters per premium dollar, number of hospital patient days, and number of inpatient admissions per premium dollar for each group. Then we standardize each scaled number of medical services per dollar for each group. That is, we subtract the mean of the unstandardized value for the group, then divide by the standard deviation of the unstandardized value for the group. Finally, we calculate the mean of the three types of standardized scaled number of medical services per dollar for each group. If an insurer does not underwrite lines of business in a specific group, the corresponding utilization will be recorded as zero. In this way, utilization reflects the total number of medical/hospital services provided per premium dollar or, alternatively, an inverse of price of coverage per utilization. Thus, utilization may capture some of the efficiency, or inefficiency, of service delivery.

Table 3.4 Variable Definitions

	Variables	**Description**
Endogenous Variables	**Capital**	Capital / Total Assets
	Asset Risk	Opportunity Asset Risk (see discussion in the text)
Predetermined or Exogenous Variables	**Working Population Product Risk**	(Comprehensive Premium Income + Federal Employee Benefits Plans Premium Income) / Total Assets
	Limited Coverage Product Risk	(Dental Premium Income + Vision Premium Income) / Total Assets
	Medicare Product Risk	(Medicare Premium Income + Medicare Supplement Premium Income) / Total Assets
	Welfare Product Risk	Medicaid Premium Income / Total Assets
	Working Population Utilization	(Standardized Number of Provider Encounters Per Premium Dollar for Working Population Group + Standardized Number of Hospital Patient Days Per Premium Dollar for Working Population Group + Standardized Number of Inpatient Admissions Per Premium Dollar for Working Population Group) / 3
	Limited Coverage Utilization*	Standardized Number of Provider Encounters Per Premium Dollar for Limited Coverage Group
	Medicare Utilization	(Standardized Number of Provider Encounters Per Premium Dollar for Medicare Group + Standardized Number of Hospital Patient Days Per Premium Dollar for Medicare Group + Standardized Number of Inpatient Admissions Per Premium Dollar for Medicare Group) / 3

	Welfare Utilization	(Standardized Number of Provider Encounters Per Premium Dollar for Welfare Group + Standardized Number of Hospital Patient Days Per Premium Dollar for Welfare Group + Standardized Number of Inpatient Admissions Per Premium Dollar for Welfare Group) / 3
	Working Population Loss Ratio**	(Comprehensive Underwriting Deduct + Federal Employee Benefits Plans Underwriting Deduct) / (Comprehensive Premium Income + Federal Employee Benefits Plans Premium Income)
	Limited Coverage Loss Ratio**	(Dental Underwriting Deduct + Vision Underwriting Deduct) / (Dental Premium Income + Vision Premium Income)
	Medicare Loss Ratio**	(Medicare Underwriting Deduct + Medicare Supplement Underwriting Deduct) / (Medicare Premium Income + Medicare Supplement Premium Income)
	Welfare Loss Ratio**	Medicaid Underwriting Deduct / Medicaid Premium Income
	Health Loss Ratio**	Health Insurance Total Underwriting Deduct / Total Premium Income from Health Insurance
	Size **Return on capital**	Geometric Mean of (Total Assets, Total Liabilities, Total Writings) Return on Capital = Total Income / Total Book Capital
	In group?	In Affiliated Group (1), Not in Affiliated Group (0)
	Stock insurer?	Stock Firm (1), Non-Stock Firm (0)
	Use derivatives?	Indicator of Derivative Activity (1=Yes)
	States of licensure	Number of States of Licensure

* For Dental and Vision insurance, majority of hospital patient days and inpatient admissions are zeros. Thus we only include doctor's visit in the utilization calculation.

** Underwriting Deduct = Total Hospital and Medical Expenses + Claims Adjustment Expenses + Administrative Expenses + Increase in Reserves

Summary Statistics

Table 3.5 profiles the health insurance industry for our study. The table shows summary statistics for all the endogenous and exogenous variables used in our analysis. All insurers that file with the NAIC under the Health category are included, except for health insurers with capital-to-asset ratio below 0 or above 1. To save space, we supply summary statistics for even-numbered years only.

Table 3.5 Summary Statistics for NAIC Health Insurers 2002, 2004, 2006 and 2008*

	2002				2004				2006				2008			
Variable	**N**	**Mean**	**Std Dev**	**Median**	**N**	**Mean**	**Std Dev**	**Median**	**N**	**Mean**	**Std Dev**	**Median**	**N**	**Mean**	**Std Dev**	**Med**
Capital ratio	731	0.525	0.246	0.481	730	0.583	0.215	0.547	821	0.593	0.225	0.571	827	0.59	0.213	0.
Asset risk	770	0.004	0.005	0.003	765	0.005	0.003	0.004	872	0.003	0.002	0.002	877	0.008	0.009	0.
Working population utilization**	428	0.325	0.728	0.183	416	0.215	1.195	0.067	419	0.493	0.908	0.284	423	0.393	1.197	0
Limited coverage utilization**	80	2.105	2.177	1.428	80	1.942	2.333	1.13	105	1.814	2.149	1.128	115	0.599	2.697	0
Medicare utilization**	187	0.927	1.313	0.449	201	0.644	1.193	0.232	283	0.574	1.172	0.127	354	0.599	1.124	0.
Welfare utilization**	165	1.436	1.008	1.16	156	1.308	1.241	1.062	163	1.28	1.063	1.103	167	1.295	1.227	1.
Working population loss ratio***	449	1.018	0.209	0.99	438	1.012	0.249	0.976	439	1.019	0.225	0.98	440	1.022	0.216	0.
Limited coverage loss ratio***	249	0.947	0.267	0.953	244	0.939	0.189	0.951	257	0.956	0.204	0.955	265	0.961	0.231	0
Medicare loss ratio***	201	0.971	0.175	0.958	220	0.975	0.232	0.963	301	1.002	0.216	0.957	377	1.01	0.238	0.
Welfare loss ratio***	172	0.996	0.162	0.991	164	1.012	0.238	0.981	174	1.012	0.27	0.984	178	1.041	0.29	0.
HealthLossRatio	700	1.003	0.223	0.985	687	0.999	0.231	0.971	761	1.01	0.231	0.976	801	1.021	0.215	0.
Size****	771	16.06	2.451	16.417	766	16.19	2.459	16.536	874	16.28	2.473	16.483	878	16.48	2.402	16.
logRBCratio	727	5.682	1.418	5.413	730	5.898	1.393	5.611	816	6.033	1.651	5.668	821	5.909	1.375	5.
Return on capital	732	0.008	1.983	0.113	732	0.097	1.186	0.138	821	0.125	0.89	0.12	827	0.283	7.046	0.
In group (1/0)	771	0.652	0.477	1	768	0.685	0.465	1	874	0.697	0.46	1	878	0.705	0.456	
Stock insurer (1/0)	771	0.728	0.445	1	768	0.727	0.446	1	874	0.732	0.443	1	878	0.736	0.441	
Use derivatives (1/0)	771	0.003	0.051	0	768	0.009	0.095	0	874	0.007	0.083	0	878	0.008	0.089	
State of licensure	771	1.405	2.576	1	768	1.582	3.593	1	874	2.055	5.341	1	878	2.534	6.904	

* Product risk proxies are not shown to save space. Product risk proxy statistics can be found in Table 2.4

** Utilization is as defined in Table 3.4. The utilization summary statistics for a particular one of the four groups omit insurers that are not active in that group. Thus N for each of the four groups is less than the total count insurers.

*** The loss ratio summary statistics for a particular one of the four groups omit insurers that are not active in that group. Thus N for each of the four groups is less than the total count of insurers.

**** Size is in log scale. Thus, a size of 16.5 corresponds to a geometric mean assets, premiums and liabilities of about $14.5 million.

We note just a few additional points about our sample of health insurers. First, comprehensive health insurance together with federal employee health benefit plans (the working population group) are the pre-dominant lines of health insurance (See Table 2.4 for product risk data). For example, in 2008, 445 of our health insurers underwrote comprehensive, and 164 of our health insurers underwrote federal employee health benefit plans (as shown in table 1.3), which resulted in 452 health insurers in the working population group. Furthermore, even though the loss ratios of the four groups vary from year to year, they are consistently in the ascending order of limited coverage group, Medicare group, Medicaid group and working population group. As we noted earlier, the loss ratio is an important indicator of health insurers' underwriting performance. In fact, a higher loss ratio on average reflects a higher risk level for a specific line of business. Thus, consistent with the theoretical foundation of TCE, the working population embodies the highest product risk level and we expect health insurers' capital structure to be sensitive to change in the working population product risk.

A brief mention of some overall comparison statistics for the Life and Health industries instructively emphasizes the distinctive character of the health insurance industry for this study. For 2008, total premiums for our sample of health insurers are more than 2.5 times total invested assets, whereas total premiums for the Life[77] industry are only about one quarter of invested assets. So the ratio of premiums to invested assets is more than ten times larger for the health insurance industry than for the life insurance industry. Cash constitutes about 17% of health insurers' invested assets, but only 5% of

[77] All insurers that report to the NAIC in the Life category.

life insurers' invested assets. So health insurers hold proportionately about 3.5 times as much cash in their portfolios as life insurers. We believe that these differences between the two industries are driven by the differences between their business products as predicted by the business strategy hypothesis.

3.2.3 Empirical Methodology

Since we view capital and asset risk as mutually interacting and endogenous, we deploy a simultaneous equation model with two structural equations, one for capital and one for asset risk. Each structural equation has its own set of predetermined/exogenous control variables, including our product risk proxies, which are treated as predetermined.

Our structural model is:

$$\begin{aligned} C_t &= \beta_0^C + \beta_C^C C_{t-1} + \beta_A^C A_t + \beta_P^C P_t + \beta_1^C X_{1t} + \cdots + \beta_k^C X_{kt} + \varepsilon_t^C \\ A_t &= \beta_0^A + \beta_C^A C_t + \beta_A^A A_{t-1} + \beta_P^A P_t + \beta_1^A X_{1t} + \cdots + \beta_k^A X_{kt} + \varepsilon_t^A \end{aligned} \quad (1)$$

where *C* is the insurer capital-to-asset ratio, *A* is the asset risk index, and *P* is the vector of two product risk indices. Although *P* is singled out to emphasize its special role in the business-strategy hypothesis, *P* is treated the same for estimation as any other predetermined/exogenous variable *X*. *A* appears in the structural equation for *C*, and *C* appears in the structural equation for *A*. This aspect of the model represents the assumed mutual interaction between *A* and *C*. The role of the lags C_{t-1} and A_{t-1} is to capture effects on *C* and *A* that are not isolated by other predictors and that are strong enough to linger on into the next year. Both A and C are used in logarithm scale in the model. The log transformation makes them more nearly normal and enables the interpretation of their coefficients as elasticities.

The estimation methodology is two-stage least squares with instrumental variables and correction for autocorrelation. In the first stage, the reduced-form model is estimated:

$$C_t = \alpha_0^C + \alpha_1^C X_{1t} + \cdots + \alpha_k^C X_{kt} + \varepsilon_t^C$$

$$A_t = \alpha_0^A + \alpha_1^A X_{1t} + \cdots + \alpha_k^A X_{kt} + \varepsilon_t^A \qquad (2)$$

Each reduced form equation is estimated separately and uses the complete set of predetermined/exogenous variables from Table 1. Of course, all endogenous variables and their lags are also excluded from the right-hand sides of (2). Since we have a panel dataset, the covariance matrix of the errors in (2) is block-diagonal, so OLS estimation should not be used. Instead we use the Generalized Estimating Equations (GEEs) methodology (Liang and Zeger, 1986) for autoregressive errors, as implemented in SAS.[78] The resulting estimated values (C_t^* and A_t^*) of C_t and A_t, respectively, are instruments for use in the second stage of the two-stage least squares methodology. Substituting the first stage instruments into the right-hand side of (1), we then estimate the second-stage model:

[78] We applied various diagnostic tests to insure that the assumptions of the model are appropriate.

	$C_t = \beta_0^C + \beta_C^C C_{t-1} + \beta_A^C A_t^* + \beta_P^C P_t + \beta_1^C X_{1t} + \cdots + \beta_k^C X_{kt} + \varepsilon_t^C$ $A_t = \beta_0^A + \beta_C^A C_t^* + \beta_A^A A_{t-1} + \beta_P^A P_t + \beta_1^A X_{1t} + \cdots + \beta_k^A X_{kt} + \varepsilon_t^A$	(3)

Each equation is again estimated separately. Use of the instruments permits asset risk to "participate" in the capital equation, and vice-versa, while removing the correlation between the endogenous predictors and the errors that makes OLS inconsistent in (1). Because of the panel data structure, we again have autocorrelated errors in (3), so we again employ GEE. Variable selection for the stage 2 models was informed by the need to insure identifiability of parameters, by the importance attached to variables by previous research, and by stepwise regression to achieve parsimonious models. The results of the second stage analysis are discussed in the next section.

3.2.4 Empirical Results and Discussion

Table 3.6 presents results for stage two of the two-stage least squares estimation methodology discussed in the methodology section. We apply the neglog transformation (referenced previously) to product risk proxies in order to adjust for skewness, yet retain insurers with zero premium income in certain lines of business. The main issues for analysis are the business-strategy, finite risk, and excessive risk hypotheses.

Table 3.6 Estimates of the simultaneous structural equations (stage 2) for capital-to-asset ratio and asset risk

	Capital Equation		Asset Risk Equation	
	Estimate	**P-Value**	**Estimate**	**P-Value**
Intercept	0.6127	0.0278	-3.3956	<.0001
Working Population Product Risk (log)	0.1213	<.0001	-0.2063	<.0001
Limited Coverage Product Risk (log)	0.0891	<.0001	-0.1284	<.0001
Medicare Product Risk (log)	0.0118	0.4764	-0.0512	0.1302
Welfare Product Risk (log)	0.0430	0.0055	-0.1469	<.0001
Asset Risk Instrument (log)	0.2450	<.0001		
Capital Ratio Instrument (log)			1.1000	<.0001
lag Capital Ratio (log)	0.2530	<.0001		
lag Asset Risk (log)			0.4242	<.0001
Size	-0.0577	<.0001	0.1395	<.0001
RBCratio (log)	0.1734	<.0001	-0.1931	<.0001
NGroup	0.0713	<.0001	-0.1322	<.0001
Health Loss Ratio	0.0630	<.0001		
Scale	0.3039	.	0.7410	.
Sample Size	*5,003*		*5,031*	
R^2	*0.5742*		*0.3200*	

The results in Table 3.6 suggest an important role for product risk as a pre-determinant of the capital ratio and asset risk, as judged by the significant coefficients of product risk. As expected, a given increase in working population product risk is associated with a greater increase in capital ratio than the same increase in product risk of the other groups. The signs of the coefficients also comport with the finite-risk hypothesis for product risk in both the capital and asset risk equations. That is, an increase in product risk is associated with an increase in capital and a decrease in asset risk.

On the issue of finite risk versus excessive risk for the interplay between capital and asset risk, we look to the coefficient of asset risk in the capital equation and to the coefficient of capital in the asset risk equation. Since both variables are in log scale, their coefficients are elasticities. The elasticity of capital with respect to asset risk is 0.245. This means that an increase in asset risk of one percent is associated with an increase in the capital ratio of 0.245 percent. The relationship is positive, which means that capital increases when asset risk increases, *ceteris paribus*. This suggests that health insurers balance an increase in asset risk with the safety of a financial risk-reducing increase in capital – in keeping with the finite risk hypothesis. Correspondingly, the elasticity of asset risk with respect to capital is 1.1. That is, an increase in capital can support a similar magnitude of increase in asset risk. This is the inverse of the case for the elasticity of capital with respect to asset risk. This, too, is consistent with finite risk.

Results suggest that product risk plays an important role in capital structure decisions of health insurers. Health insurers respond to the product risk increase by building up more capital, which is consistent with the finite risk hypothesis. The responsiveness of capital to different product risk proxy depends on the product risk level as we identified in Section 2.2.1. The working population coefficient of 0.1213 is highest among the groups of product lines. More capital is needed to mitigate an increase in the product risk of comprehensive and FEHP insurance because these products embody the highest level of product risk. Compared to private insurance groups, Medicare and welfare groups put much less pressure on insurers' capital structure. The coefficient of the welfare group is only 0.043, about one third of the working population group. Though positive, the coefficient of the Medicare group is not significant. Therefore, health insurers' major product risk concerns lie in the working population and the limited coverage groups, which are their private or commercial lines of business. Finally, there is some question as to whether product risk should be treated as endogenous. To test this, we applied the Durbin-Wu-Hausman test (Wooldridge, 2002), which confirms our treatment of capital and asset risk as endogenous and of the product risks as non-endogenous.

A further technical issue involves the potential for survivor bias in our sample. In selecting our sample, we elected to use whatever insurers reported to the NAIC in the Health category each year. As some insurers dropped out of the sample on account of merger, acquisition, insolvency, or other reasons, other insurers were allowed to join. So survivor bias, understood as the biasing effect of sample attrition, does not apply to our panel. We elected to allow the panel to vary from year to year in order to reflect the actual composition of the industry. An alternative would have been to select all insurers present in the data in all eight years, 2001-2008. The alternative could be criticized for biasing results toward large insurers, since small insurers are more likely to leave or join the panel over time. As a test of the robustness of our analysis, we ran the same analysis with the alternative stable panel of insurers. We found much the same results as shown in Table 3.4. In the interest of space, we do not show those results here.

For the remaining predetermined/exogenous predictors in Table 3.6, we observe that their coefficients are generally consistent with previous literature for other sectors of the insurance industry. As might be expected, the lags of the endogenous variables are highly significant in their own respective equations. The lags embody the composite effects of a host of factors that are not explicitly measured by our models – just offset by one year. Size is negatively related to capital-to-asset ratio, which suggests that large firms may feel that their size itself confers a partial measure of safety. RBC ratio is positively related to capital-to-asset ratio. Firms close to the threshold of regulatory scrutiny (low RBC ratio) are associated with lower capital levels and higher asset risk. High returns on capital contribute to capital accumulation. In the asset risk structural equation, we see that large firms tend to hold riskier assets, perhaps feeling that size offers a partial offset to risk – a view that may have been shaken by the 2008/2009 financial crisis.

Summary

Findings and Contributions

Life Insurance Industry

In the life insurance industry, we identify a new product risk created by guarantees of VAGLB products. We introduce *guarantee risk*, a new proxy, to measure VAGLB product risk. The guarantee risk innovation is based on simulation of future bond and equity returns using methodology developed by VARWG. The simulated returns are applied to model portfolios of VAGLB annuitants. Deficiencies occur when poor market returns cause actual portfolio values to lag behind guarantees. The guarantee risk metric is a value-at-risk measure equal to the mean of the worst 30% of deficiencies in a 10,000-iteration simulation of the next 30 years.

We further study how variable annuities with guaranteed living benefits (VAGLB) affect the capital ratio of life insurers. Using a capital structure model that includes asset risk and guarantee risk in a context of other enterprise risks and controls, we find support for both the "finite risk" and "excessive risk" regimes in the industry. In particular, increased asset risk is accompanied by increased capital (finite risk prevails), *ceteris paribus*. But less capital is held as guarantee risk increases (excessive risk prevails). Since lower capital ratios are also associated with use of derivatives, it may be that insurers view their hedging activities as providing adequate coverage for the new risks of variable annuity guarantees.

Health Insurance Industry

The health insurance industry is a critical intermediary between health care consumers and health care providers in the U.S. The financial health of health insurers is thus of great importance and may become even more so after the passage of PPACA.

In this dissertation we focus on the relationship between capital and two major types of risks of health insurers: product risk and asset risk. These relationships have been studied previously for the life insurance, property/casualty insurance and banking industries. This is the first study to provide such examination for the health insurance industry. The study provides important principles for predicting the behavior of the health insurance industry as it reacts to new legislative and regulatory requirements, such as those of PPACA. Therefore, we test whether the industry manages its capital vis-à-vis investing and underwriting in a risk-limiting or risk-seeking manner and assess the strengths of those relationships. We also examine evidence for the *business-strategy* hypothesis that suggests choices of capitalization and investing risk can be viewed as flowing from a prior choice of product risk level. To aid our investigation, we create product risk proxies in line with the concepts of transaction cost economics theory, especially heeding the consequences of incompleteness of contractual promises.

Our study uses all U.S. insurers that report to the NAIC as health insurers during 2001-2008. We find that our panel of health insurers acts to limit risk by balancing an increase of one type of risk with a decrease in another type. We also find support for the business-strategy hypothesis. The results of our research show that the industry is operating under the “finite risk” paradigm and that the elasticity of capital with respect to asset risk is low.

Empirical tests support our underlying theoretical view: For health insurers, product risk acts as a predetermined driver of endogenous, mutually interacting capital and asset risk decisions. Furthermore, our empirical findings suggest that health insurers take compensatory offsetting actions in other areas to deal with regulatory or other actions that increase their risk. The major elements of PPACA – uncapping benefit limits, guaranteeing coverage to all, and loss ratio minima – add to product risk. If insurers remain within the realm of finite risk, they will seek to offset these increases in product risk. Whether they increase capital or re-price their products, or some combination, depends upon the size of the required adjustments, access to capital markets, regulatory and consumer resistance, and competition.

Future Studies

Life Insurance Industry

While examining life insurers’ risk-taking behavior towards the new product risk, the guarantee risk, we have another interesting finding: life insurers’ capital is negatively related to the guarantee risk controlling for derivative hedging. A possible explanation is that life insurers rely on derivatives hedging as a viable risk management tool so much that they decrease the capital level. This observation is consistent with findings in the other industries (see Leland 1998, Purnanandam 2008 and Lin et al 2008). And we also notice that the elasticity of capital to asset risk in our capital structure model is lower than what is found in similar studies for the life insurance industry (see Baranoff and Sager 2002, 2003). A possible explanation could be that life insurers reorganized their risk metrics and took more overall enterprise risks using derivatives hedging as a flexible and effective risk management tool.

Are life insurers relying on derivatives as a viable risk management tool? It is a serious question to be answered based on what we've found in life insurers' current risk-taking behavior. With more product risk or asset risk and less capital, life insurers are more likely to experience financial distress or even insolvency. Moreover, the use of derivatives is found mostly in large insurers that are systemically important. Their financial well-being is critical to the whole life insurance industry. Therefore, our future research might address issues such as:

Whether life insurers' performance changes with the involvement of derivatives hedging;

Whether life insurers' risk-taking behavior changes with the involvement of derivatives hedging;

Whether life insurers' risk-taking behavior changes differently with the involvement of derivatives hedging for stock vs. mutual insurers;

Whether life insurers' performance change is caused by the change of risk-taking behavior or the increase of overall risk;

Whether the volatility of life insurers' performance changes as well, which we hope to find some evidence from the 2008 – 2009 crisis;

Health Insurance Industry

In the health insurance industry, we find the risk proxies for health insurers' product risk and asset risk and build a preliminary capital structure model. Consistent with our expectations, health insurers are also operating under a risk-limiting mode. Our research on capital structure in the health insurance industry is the first one to our knowledge. However, it is just a start.

In our research, we notice that health insurers operate under a complicated health care delivery system. Health insurers' customers and claimants are different agents. Health insurers that file with NAIC have more organizational forms as well (BC/BS, HMO, and insurers). Health care services are delivered through various managed care networks (HMO, PPO, PSO and PSO). Health insurance products are riskier products on average. And factors such as coverage, age group and source of premiums all contribute to uncertainties. Meanwhile, health insurers' annual statements provide more detailed information such as medical services utilization and expenses. There are numerous interesting topics that can be studied based on the above features we identified.

Currently, a topic to our great interest is the cost of health care. It is also a current concern in healthcare economics but mostly from a macroeconomic perspective (see Okunade and Murphy 2002, Hartwig 2008 and Buchmueller et al 2005, etc.). However, with detailed NAIC health insurers' annual statements, our perspective is on the micro-level. Our key question is: what is the relationship between healthcare costs and health insurers' financial management? Financial management is a broad concept, which can involve health insurers' organizational form, capital structure, asset risk, product risk, etc. Cost might also have a number of representations for insurers such as medical expenses, claims, and utilization. Our goal is to study what features of financial management help to control or lower healthcare cost for insurers controlling for other factors such as coverage and managed care network.

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